EnSlope v2025 – User's Manual

A Program for Slope Stability Analyses

by

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CHAPTER 1. Introduction

1.1 General Description

Program EnSlope has been developed by Ensoft for the solution of slope-stability problems using a two-dimensional limit-equilibrium method. EnSlope uses intuitive graphical screens for data input, where users can draw or define graphics of the slope geometry and soil layers and also view graphics of output results.

The new EnSlope software is based on enhancements of the methods for slope stability analyses established by the STABL series of programs, initially developed by Ronald A. Siegel at Purdue University in 1975. The original STABL has been available since 1976, with an open release from the Indiana Department of Highways. After its release in the open literature, the program was later adopted by many other agencies. Currently, the STABL programs are well accepted tools for analyzing the stability of slopes by various state highway agencies in the United States.

The original STABL programs were developed for mainframe computers and adapted to personal computers using a command-line format for data entry. The new EnSlope uses enhanced-graphics interface to implement pull-down menus, dialog boxes, option buttons, and grid-cells for data entry. The user may read information on the screen, then type input at the specified entry field. The entered data can be easily changed by moving the mouse to the location of a particular field. The graphics module allows the user to view failure surfaces, boundary lines, water surfaces, surcharge loads, and other features.

In addition, EnSlope allows the user to analyze a reinforced-earth slope as well as a slope stabilized by piles or drilled shafts. It also allows for the use of either English units (ft and lbs) or S.I. units (meter and kN). The program helps with unit conversions if the user selects to change from one system of units to the other.

1.2 Features of the Program

EnSlope was developed for Windows platforms (Windows 7 and newer) and utilizes a graphical interface for data entry. Users can view the on-screen information and then type the data at the specified entry field. The entered data can be changed freely by moving the mouse to the field location on the screen.

EnSlope integrates the input modules, main-computation module, and graphics module into a single system, allowing users to seamlessly access each module within the Windows environment. Generally, after entering the input data, users can utilize the computation module to execute the model. Additionally, the graphics module can be used to plot the computed potential failure surfaces. The concept of "a picture is worth a thousand words" is used to define most of the geometrically-related input parameters.

EnSlope features unique random techniques for generating potential failure surfaces, which are then used to determine the most critical surfaces and their corresponding factors of safety. One technique generates circular failure surfaces, while another produces general, irregular surfaces of random shapes. The current version of EnSlope can handle tieback loading, reinforced-earth layers in embankments, and Spencer's method of analysis.

1.3 History of Development

1.3.1 STABLPRO1 (1995)

With the advent of the widespread availability of personal computers, the founder of ENSOFT, Inc., had a vision to improve the engineering capability for the analysis and design of deep foundations by providing useful software tools. The development of STABLPRO1 was completed under the direction of Dr. Lymon C. Reese and was first commercially distributed in 1987. While based on an earlier mainframe program, STABLPRO1 was developed to use an interactive input method.

1.3.2 STABLPRO, Version 1 (1995)

STABLPRO v1.0 was released in 1995. The success of Windows 3.1 from Microsoft, Inc., as the dominant platform for personal computers pushed software development to adopt a standard, graphical-user interface. This first version of STABLPRO utilized Windows-based pre- and post-processors while retaining the original computing engine from STABL4M.

1.3.3 STABLPRO, Version 2 (1998)

This version of STABLPRO was a complete recoding of both the pre-and post-processing programs running under Windows 95/NT and the computing engine. The windows-graphical-user interface was rewritten to provide a more intuitive process for data input and to enhance the graphical capabilities.

1.3.4 STABLPRO, Version 3 (2004)

This version of STABLPRO is upgraded for the requirement under Windows 2000/XP and the later system. The most recent files of the input data will be listed under the File Menu for users to load or retrieve quickly and conveniently.

STABLPRO Version 3 adds an option to analyze the reinforced-earth slope. The user-defined soil layers and profile coordinates can be seen on the graphical windows for easy identification of any mistakes in data entry.

1.3.5 STABLPRO 2015, Version 4 (2015)

STABLPRO has used the year number as the version sequence starting in 2015 while keeping the second number of the release aligned with the input data format (input data format 4). The major improvement in v2015.4 was a complete rewrite to create a more intuitive interface within the Windows 8 environment.

The new release also introduces many practical examples for users' references. In addition, the program textbook was updated and released in separate User’s and Technical Manuals, both improved plus released electronically in protected PDF format.

1.3.6 EnSlope 2025, Version 1 (2024)

The STABLPRO program has been thoroughly enhanced and has now evolved into the new EnSlope program. In this version of EnSlope, a display of the input data is available even before running the analysis allowing the user to verify that the graphic is consistent with the input data. It also introduces the option to define surcharge loads with linear variation. For reinforcement layers, the program now offers the ability to account for variations in both axial force and shear force. Additionally, both the user manual and the technical manual have been revised.

1.4 Organization of EnSlope Manuals

The documentation provided with the computer program EnSlope consists of two volumes. The User's Manual contains full documentation about the operation of the program on personal computers. The User's Manual covers the areas of installation, preparation of input data, program execution, view of computational results, and example applications. The distribution of the User's Manual is made via standard Adobe© PDF file format.

The Technical Manual provides information about the theory and different methods used for slope stability analyses. The Technical Manual includes other helpful references related to concepts utilized in the EnSlope program.

Both Manuals are installed with the EnSlope program and accessible via any one of the following three methods: i) from the Windows Start Menu, ii) from the Ensoft tile in Windows, or iii) from the Help menu within the EnSlope program.

1.5 Typographical Conventions

To orient the user to different software features, certain terms are set in typefaces that distinguish them from the body text. The following formatting conventions are used throughout the Manual:

- Commands that are typed directly on the keyboard: "Enter"; "F1"; "Esc"
- Commands with keys simultaneously pressed in the keyboard: "Alt+F"; "Ctr+O"
- Menu items and other text displayed on the screen are in sans serif:
  From the File menu choose Open
- File names and names of directories and folder and icon names are in italics:
  Open the example file *example1.sfd*
- Internet and electronic mail addresses are underlined:
  Send email to support@ensoftinc.com

1.6 Contents of the EnSlope Package

The standard package sent with EnSlope consists of the following items:

- One USB Key (sometimes known as hardware key or dongle),
- One USB Memory Stick with installation programs for all Ensoft software products (this may be missing in future releases, since the full program is available for downloading from the www.ensoftinc.com website).

1.7 Default Installation Directories

The directories for installation of program files and for example files are selected by the user during program installation. Default values are provided by the installer and confirmed or changed by the user.

1.7.1 Directory for Main Program Files

Program files are installed by default in the following directory:

Root Drive:\Program Files (x86)\Ensoft\EnSlope2025

In most cases the *Root Drive* is the *c:* drive so the default is:

c:\Program Files (x86)\Ensoft\ EnSlope2025

Main program files are the following:

EnSlope2025.exe .... is the main Windows-program module (executable/application),

EnSlope2025_DLLL.dll............. is the program engine for direct computations.

Technical and User's Manuals are also included in the main installation directory.

1.7.2 Directory for Example Files

Several modeling examples with input files (files with name/extension of the type *filename.py7d*) are installed on a separate folder that defaults to:

Root Drive:\Ensoft\EnSlope2025-Examples

In most cases the *Root Drive* is the *c:* drive so the default is:

c:\Ensoft\EnSlope2025-Examples

1.8 Hardware Requirements

To use EnSlope, the user needs the following minimum hardware configuration:

- Any personal computer with an Intel® Pentium® or newer processor.
- A hard disk with at least 200 MB of free space.
- Microsoft Windows® 7, 8, 10 or 11. A newer release of the Microsoft Windows® operating system may need a more recent update of the EnSlope software.
- Minimum of 2 GB of free RAM memory.
- A mouse or similar pointing device.
- Optional: Any Windows-compatible printer.

1.9 Technical Support

The technical staff at ENSOFT strongly supports all registered users with questions related to the installation or use of EnSlope, according to the stipulations presented below. The software is provided with free maintenance service for the first year. After the first year, the user is encouraged to purchase the yearly maintenance services. The yearly maintenance services include free download of the latest version and free technical support as described below.

1.9.1 Preferred Methods of Software Support

Software support is given, in order of preference, by the following methods:

- Electronic mail to: support@ensoftinc.com

- Telephone call to: (512) 244-6464, extension 2

Users are encouraged to utilize electronic means of support via email. In all technical support requests via email, please include the following information:

- full software version/release/update (obtained from the Help > About dialog),
- a description of the user's problem or concern,
- attach a copy of the input-data file that is associated with the issue/concern (files with name/extension of the type *filename.slpd*), and
- name and telephone number of the contact person and of the licensed user (or name and office location of the licensed company site and/or serial number of the USB Key).

Although immediate answers are offered on most technical support requests, please allow up to two business days for a resolution in case of difficulties or schedule conflicts.

1.9.2 Support by Telephone

Technical help through direct calls to our local telephone number (512-244-6464) is available, but limited. The current policy of ENSOFT is that all telephone calls for software support will be answered free of charge for the first 15 minutes of each call if the user has a current maintenance policy. A charge of $90.00 US dollars per hour ($1.50 US dollars per minute) may come into effect for every additional minute after the initial 15 minutes. Applicable charges will be billed to the user.

Software support by any of the methods (fax, email, or telephone) is free for all users who have a current annual maintenance policy.

1.9.3 Upgrade Verification and Internet Site

The software provides options for the user to check the most recent maintenance release through an internet connection by selecting Help > Check for Updates. This command starts the default internet browser and will display the user's maintenance expiration date, the user's software release number, and the most recent release number that is available for download.

If the user's version is not the latest version and the maintenance has not expired, the user can download the latest version from our web server directly (www.ensoftinc.com). Users may also consult our website for additional information on software updates, demos, and new applications; technical news; and company information.

1.9.4 Renewal of Program Maintenance

The cost to renew program maintenance will depend on the length of time for which the program maintenance has been expired. There are small price increases with time after expiration. The pricing policy for renewing a program maintenance that has not expired can be found on the Ensoft website at https://www.ensoftinc.com/order_form

1.9.5 Changes in Support Policy

The software support policy and associated expenses are subject to change at ENSOFT's discretion and without specific mailed notices to the users. However, any change of rules will be verbally provided during telephone calls for software support.

CHAPTER 2. Installation and Getting Started

2.1 Installation Procedures

The EnSlope software licenses are provided with an associated USB Key (hardware key or dongle) or as cloud subscriptions with yearly renewals (no USB Key). The USB Key consists of a device that is attached to an empty USB port (or USB hub) of the computer in use (or in the designated software server in the case of local network licenses).

Users with standard single-user licenses (USB Key) can check the following link to a PDF with Installation Notes:

https://www.ensoftinc.com/doc/Ensoft_Single-User_License_Installation_Booklet.pdf

Users with local network licenses (USB Key) can check the following link to a PDF with Network Installation Notes:

https://www.ensoftinc.com/doc/Ensoft_Network_License_Installation_Booklet.pdf

Users with cloud subscription licenses (no USB Key) can check the following link to a PDF with Installation Notes:

https://www.ensoftinc.com/doc/Ensoft_Cloud_Subsc_License_Installation_Booklet.pdf

2.1.1 Installation of Single-User Version

This version of EnSlope has been tested to be compatible with the following versions of the Microsoft Windows® operating systems: Windows 7, 8, 10, and 11.

The following guidelines are recommended to be followed during the installation process of EnSlope for single-user licenses.

1. Plug the supplied USB Key into one of the available USB ports in your computer. The USB Key is plug-and-play compatible so the operating system will recognize the USB Key automatically and a small solid green light should appear at the end of the USB Key (a flickering green light or no light indicate problems with the standard windows driver or with the USB Key).
2. If the user installs from a distribution USB Memory Stick and the main installation program does not start automatically upon insertion of the Memory Stick then click on the Windows Start Menu button and select Run. On the command line, type *d:\setup.exe* or *e:\setup.exe*, where *d:* or *e:* represents the drive that contains the distribution Memory Stick. Click OK to execute the command and start the main installation program for ENSOFT's software. A screen similar to the one in Figure 2.1 should appear.

   If the user installs from a downloaded file, then please run the downloaded file (double click) and go to instruction #4.
3. Click anywhere on the EnSlope 2025 icon and then click on the Install Standard button to start the installation of EnSlope.
4. The user should read the license agreement (partly shown in Figure 2.2). Users may also review the License Agreement online in the following link:

   https://www.ensoftinc.com/doc/Ensoft%20License%20and%20Disclaimer.pdf
5. The installer will place the same file (*Ensoft License and Disclaimer.pdf)* in the installation directory. Please click Yes if you agree and would like to proceed.

5. Select Single-User License in Figure 2.3 then click Next. For cloud installations see Section 2.1.2. For network installations see Section 0.
6. The user will be provided with an option to select a drive and directory for the installation of example files (see Figure 2.4). Default installation directory is the following:

   (Root Drive):\Ensoft\EnSlope2025-Examples

7. The user will also be asked to select a drive and directory for the installation of PYWALL (see Figure 2.5). Default installation directory (varies according to the Windows release where it is installed) is one of the following:

   (Root Drive):\Program Files (x86)\Ensoft\EnSlope2025

   (Root Drive):\Program Files\Ensoft\EnSlope2025

   If the desired directory does not exist, the installation program will automatically create a new directory in the chosen hard drive.

6. During the installation the user will be asked to set the file extension association for opening EnSlope v2025 input data files (see Figure 2.6). If the user agrees (leaves the default check mark) then double clicking (or running) any input data file with extensions of the type *filename.slpd* will start the installed EnSlope v2025 software.
7. The user will be prompted to confirm the shortcut directory name that will be created in the Windows Start Menu (See Figure 2.7). The default is *Start Menu/Programs/Ensoft/EnSlope2025* Windows 11, 10 and 8 will automatically create an Ensoft tile with the same shortcuts.
8. After copying files, the installer may check if the user's Windows OS has the necessary Microsoft Visual C++ drivers. If those are not found the user will be prompted to install (Figure 2.8) and must agree to terms and select the Install button. If the drivers are present, the user will be prompted with Figure 2.9 where it can simply select the Close button.

After the installation is finished, it is usually not necessary to reboot Windows for the program to run. The user may run the program by selecting EnSlope v2025 from the standard links installed in the Microsoft Windows® Start Menu: Start Menu > All Programs > Ensoft > EnSlope2025

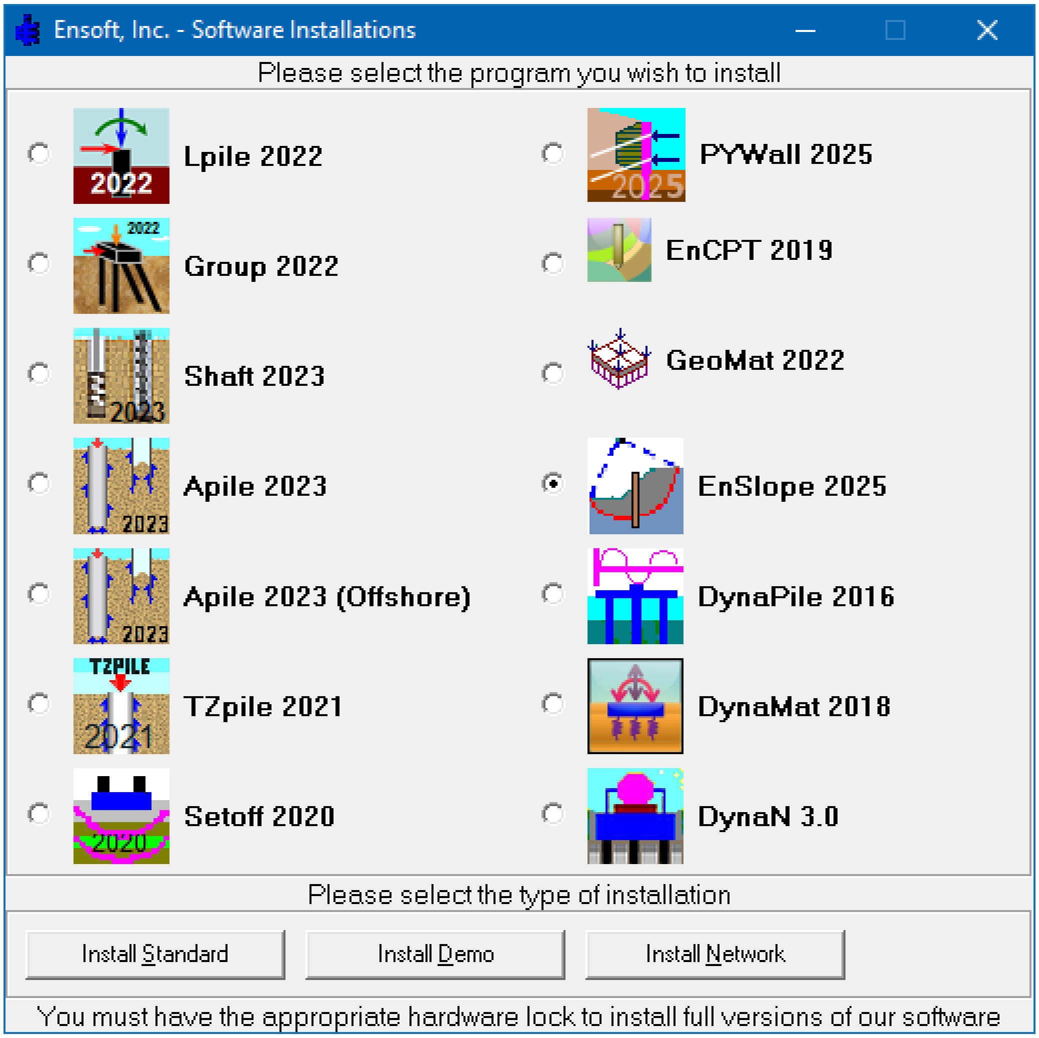


Figure 2.1 Main Installation Screen for ENSOFT Software (may change with time)

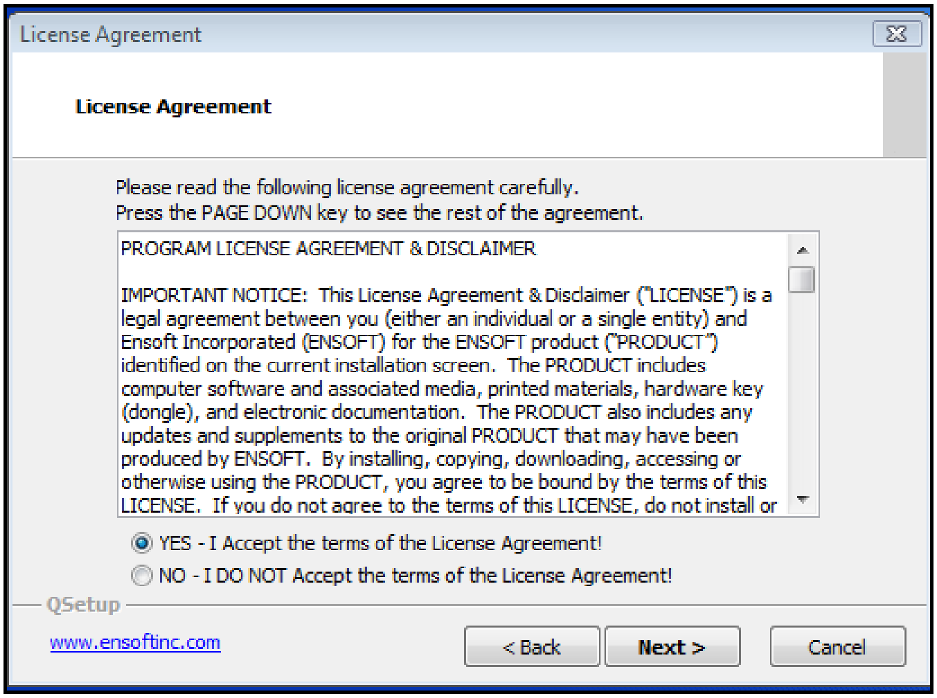


Figure 2.2 Installation screen with License Agreement (may change with time)

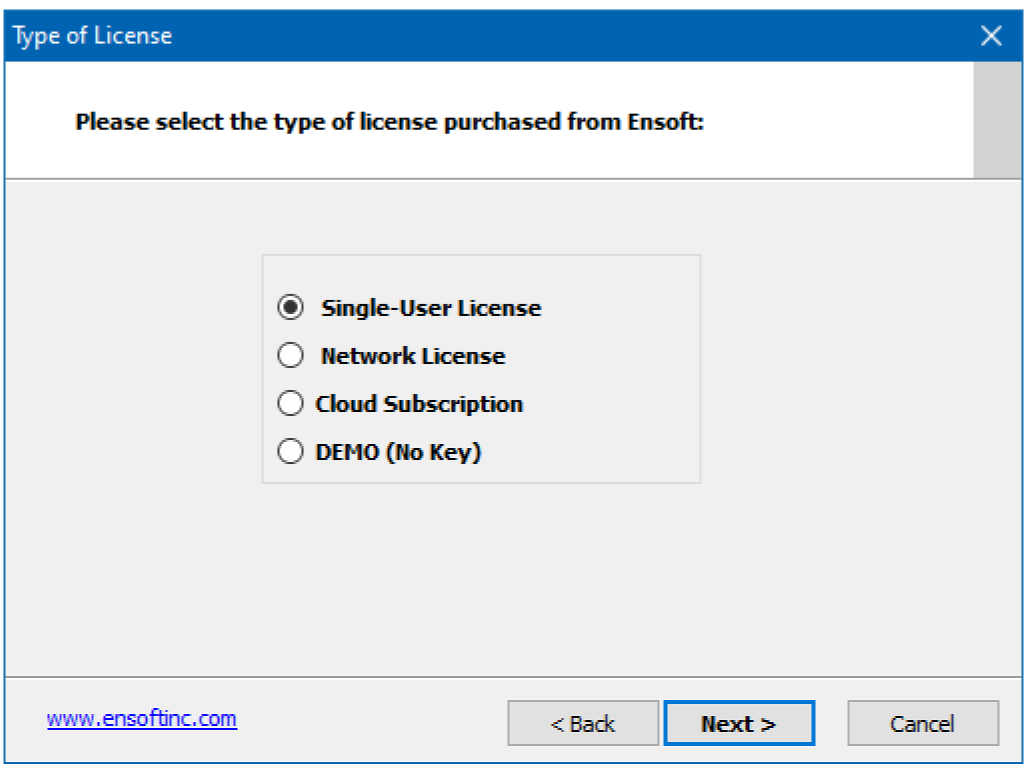


Figure 2.3 Selection of Single-User License (may change with time)

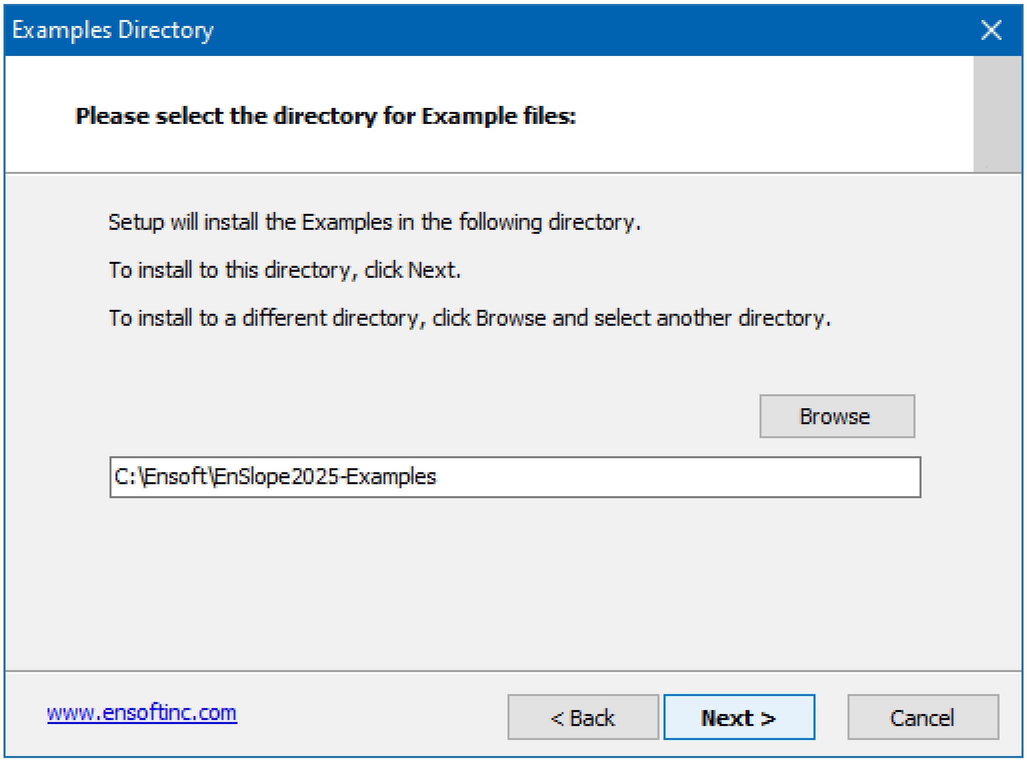


Figure 2.4 Default Installation Directory for Example Files (may change with time)

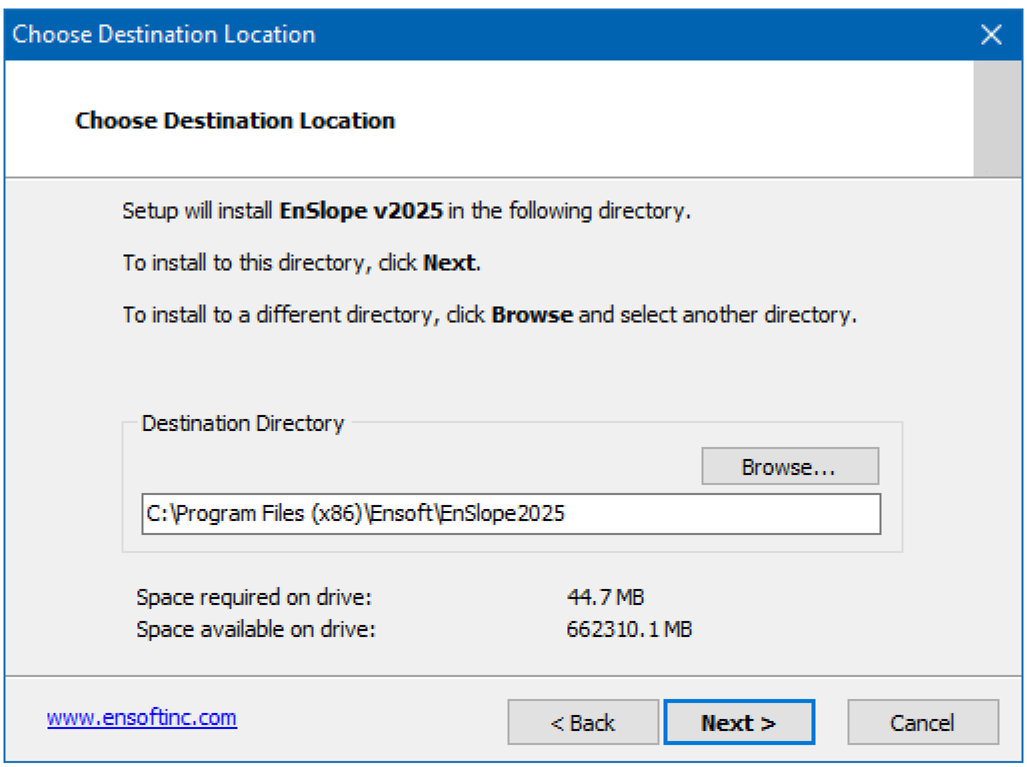


Figure 2.5 Default Installation Directory for Program Files (may change with time)

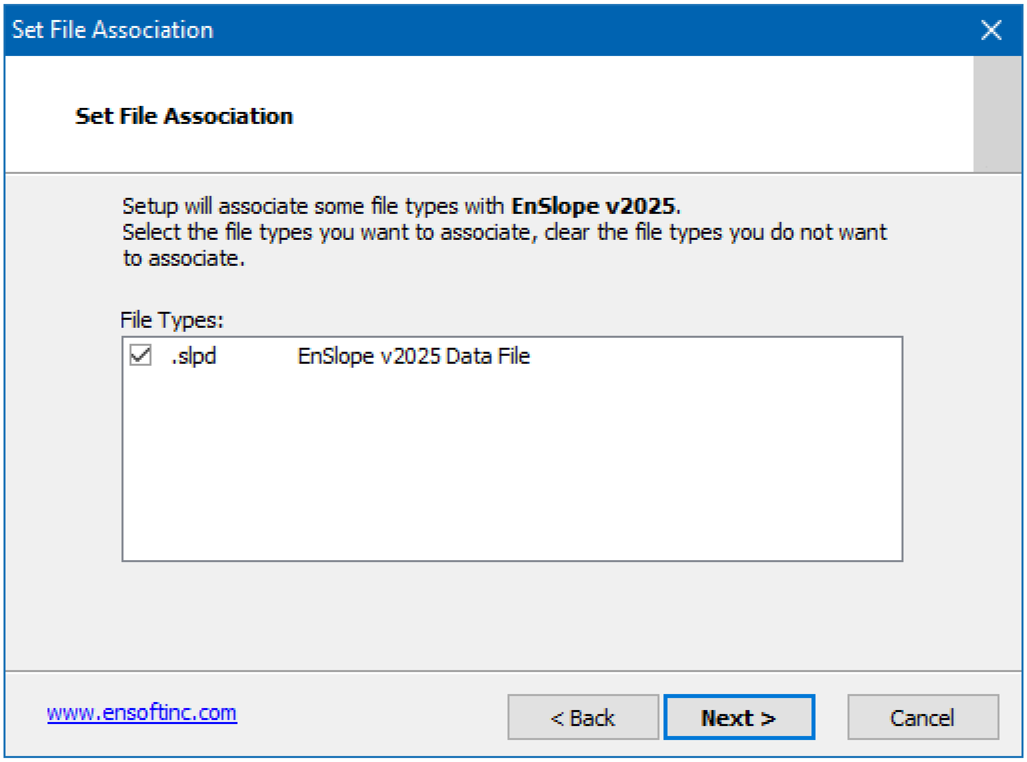


Figure 2.6 File Extension Association for EnSlope Data Files (may change with time)

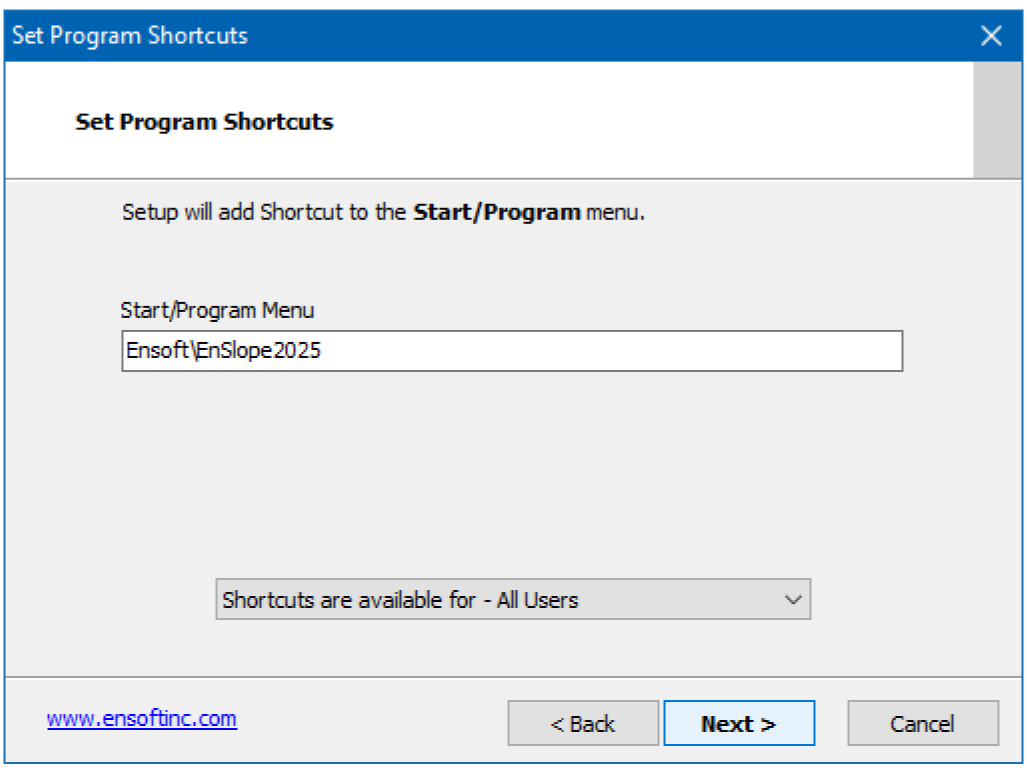


Figure 2.7 Default Shortcut Folder in Windows Start Menu (may change with time)

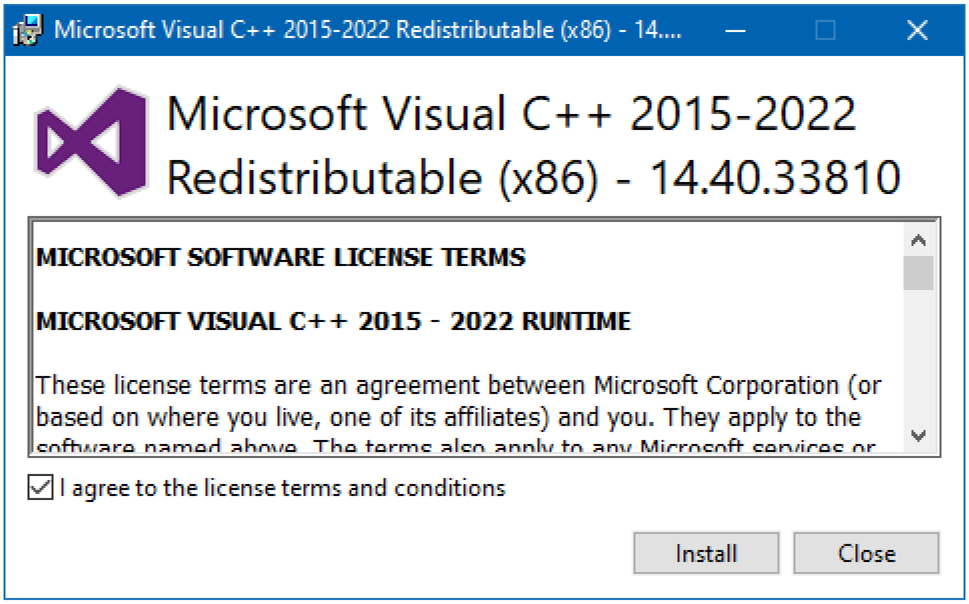


Figure 2.8 Consent for Installation of Microsoft Visual++ Drivers

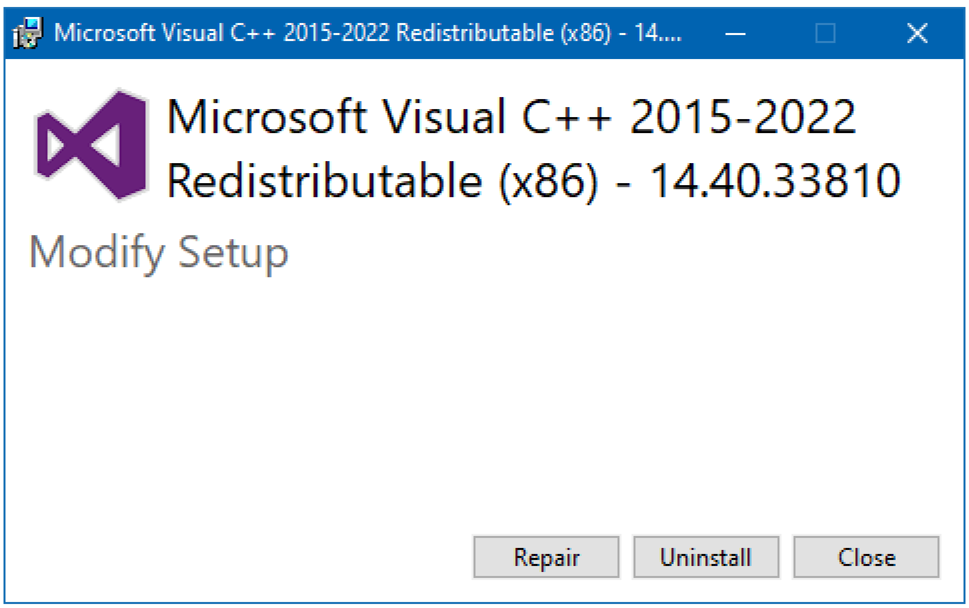


Figure 2.9 Found Installed Microsoft Visual++ Drivers

2.1.2 Installation of Cloud Subscription Version

The latest Ensoft Software updates are compatible with all recent versions of the Microsoft Windows® operating system, including 11, 10, 8.1, 8, 7, Vista, XP and 2000. The following guidelines are recommended for the installation of cloud licenses.

1. Download the purchased Ensoft Software from our website using the following link:

   https://www.ensoftinc.com/downloads

   Run (double click) the downloaded executable file and select Next to continue.

2. The user should read the license agreement (partly shown in Figure 2.2). Users may also review the License Agreement online in the following link:

   https://www.ensoftinc.com/doc/Ensoft%20License%20and%20Disclaimer.pdf

3. The installer will place the same file (*Ensoft License and Disclaimer.pdf)* in the installation directory. Please click Yes if you agree and would like to proceed.

3. Select Cloud Subscription in Figure 2.3 then click Next. For single-user installations see Section **Error! Reference source not found.**. For network installations see Section 0.

4. The user will be provided with an option to select a drive and directory for the installation of example files (see Figure 2.4). Default installation directory is the following:

   (Root Drive):\Ensoft\EnSlope2025-Examples

5. The user will also be asked to select a drive and directory for the installation of PYWALL (see Figure 2.5). Default installation directory (varies according to the Windows release where it is installed) is one of the following:

   (Root Drive):\Program Files (x86)\Ensoft\EnSlope202

   (Root Drive):\Program Files\Ensoft\EnSlope2025

   If the desired directory does not exist, the installation program will automatically create a new directory in the chosen hard drive.

6. During the installation the user will be asked to set the file extension association for opening EnSlope v2025 input data files (see Figure 2.6). If the user agrees (leaves the default check mark) then double clicking (or running) any input data file with extensions of the type *filename.slpd* will start the installed EnSlope v2025 software.

7. The user will be prompted to confirm the shortcut directory name that will be created in the Windows Start Menu (See Figure 2.7). The default is *Start Menu/Programs/Ensoft/EnSlope2025* Windows 11, 10 and 8 will automatically create an Ensoft tile with the same shortcuts.

8. After copying files, the installer may check if the user's Windows OS has the necessary Microsoft Visual C++ drivers. If those are not found the user will be prompted to install (Figure 2.8) and must agree to terms and select the Install button. If the drivers are present, the user will be prompted with Figure 2.9 where it can simply select the Close button.

After the installation is finished, it is usually not necessary to reboot Windows for the program to run. The user may run the program by selecting EnSlope v2025 from the standard links installed in the Microsoft Windows® Start Menu: Start Menu > All Programs > Ensoft > EnSlope2025

2.1.3 Introduction of Network Version

Special network licenses and USB hardware keys (network keys) are available for users that want to operate EnSlope on a Windows network. A network version is licensed for employees of one or more specific office sites that are within white listed subnets. Discounted rates apply for purchases of multiple network seats.

Network versions of EnSlope have special subroutines written for installations in "license manager" and for installations of "individual clients". The "license manager" is known as the computer that will be carrying the network key provided by ENSOFT, INC. The license manager is not necessarily the same as the existing network server but rather just a computer carrying the network key and managing the license.

Any computer in the existing Windows network may be designated license manager for EnSlope as long as the network key is attached to an available USB port (or through an USB hub) and the "server" version of the software (or of the Ensoft Utilities) is installed on its hard drive. Software "clients" may be all other computers of the network that have the program installed as client. Client computers do not need any hardware key attached to their local system. The program installed in "client computers" will be allowed to run as long as the computer designated as "license manager" is accessible on the network with the proper operating system and with its network key secured in place.

Installers of network licenses should refer to a separate booklet with installation instructions for the Network version of this product. The document can be downloaded from the Ensoft web site:

https://www.ensoftinc.com/doc/Ensoft_Network_License_Installation_Booklet.pdf

Alternatively, the document can be requested via email to support@ensoftinc.com

2.1.4 Silent Installations of Single, Client or Cloud Licenses

For installation of single-user licenses, cloud subscription licenses and network licenses on local client computers (not on License Server) there is an option for command-based installations that are completely silent (performed without other user input). Instructions for silent installations can be downloaded from the Ensoft web site using the following link:

https://www.ensoftinc.com/doc/Silent_Single-Client-Cloud_Installations.pdf

Alternatively, the document can be requested via email to support@ensoftinc.com

2.1.5 Backup of Original Software

The distributed software may be copied for backup purposes. The program may be installed in several computers. However, unless network or office cloud licenses are purchased, the program will only operate in the computer that carries the appropriate USB Key.

2.1.6 Software Updates on the Internet

Occasionally, ENSOFT will produce software improvements and/or fixes and place the latest software programs on ENSOFT's internet site. Users can check for available updates by selecting Help > Check for Updates from the PYWALL menu. Software users may freely download the latest program update from the PRODUCTS > Downloads link in the following site: *http://www.ensoftinc.com*

2.2 Getting Started

A general diagram showing the menu choices and operational flow chart of the program EnSlope is presented in Figure 2.10. The following paragraphs provide a short description of the operational features of EnSlope and should quickly enable the user to get started with the program.

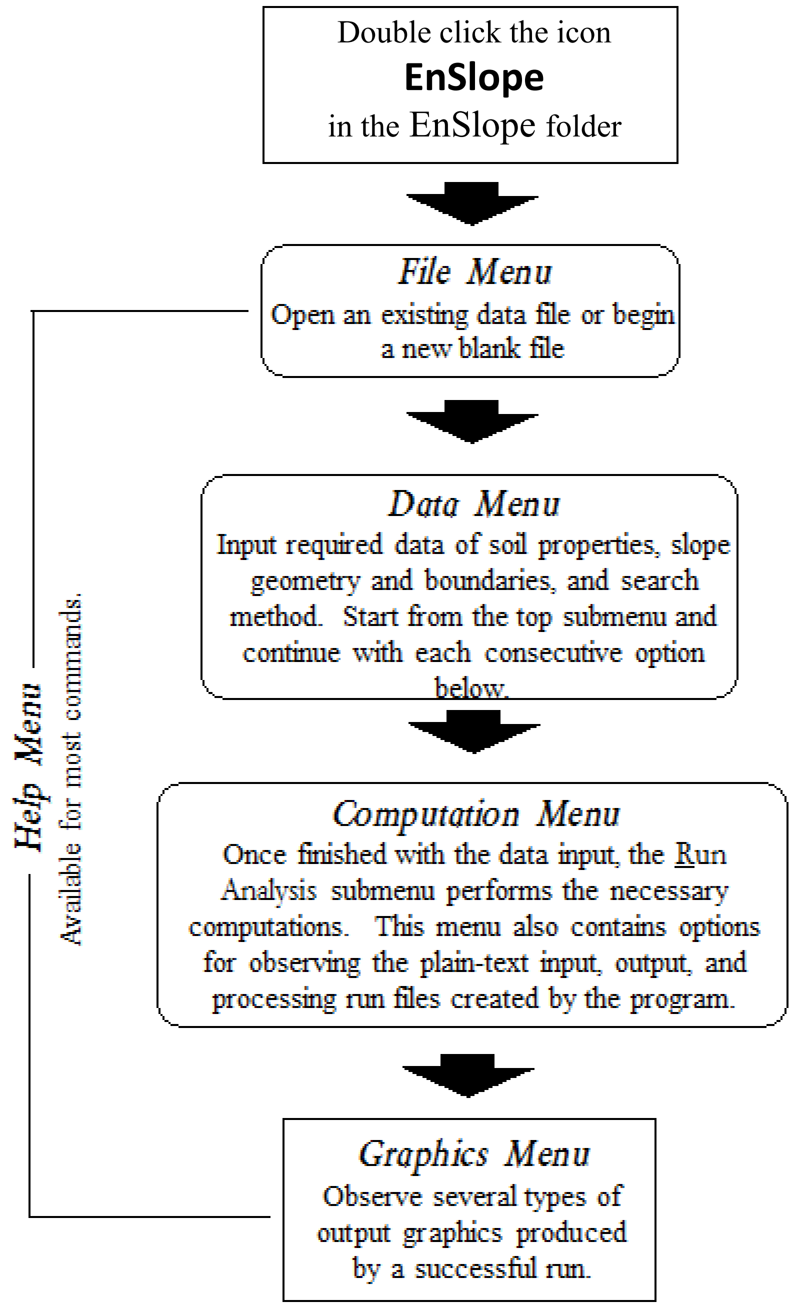


Figure 2.10 Sample organization and operational flow chart

2.2.1 Starting the Program

The program is started by double-clicking the left mouse button anywhere in the EnSlope icon. A new window will appear on the screen, with the following top-menu choices: Mode, File, Data, Options, Computation, View, Window, and Help.

2.2.2 Mode Options

The Mode menu option contains two submenus, as shown in Figure 2.11; they are:

- Input Mode to define a new model or edit an existing model.
- Results Mode to view the results available after a successful run.

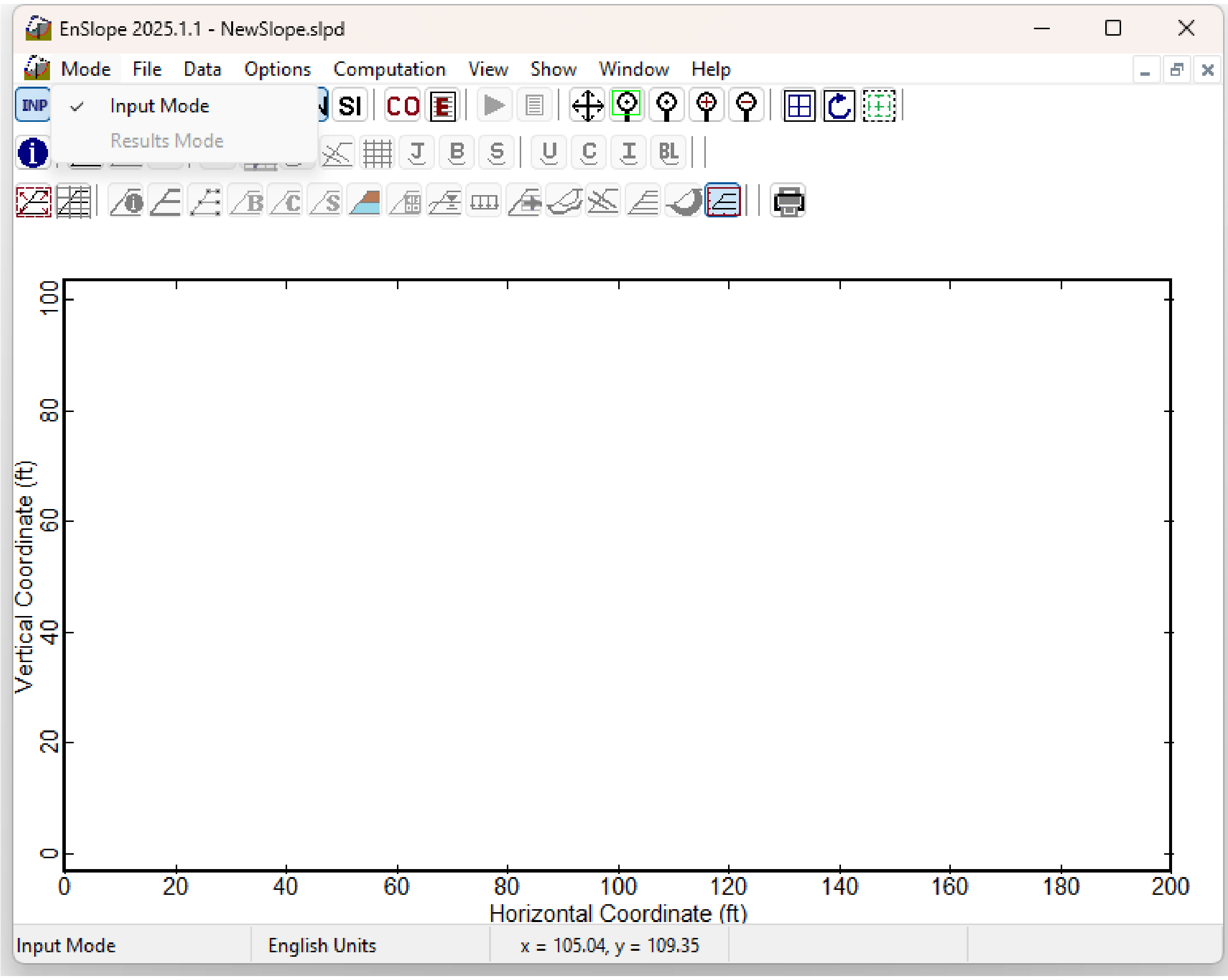


Figure 2.11 Options contained in the Mode menu

2.2.3 File Management

The File menu option contains five submenus, as shown in Figure 2.12; they are:

- New to create a new data file.
- Open… to open an existing data file.
- Save to save input data under the current file name.
- Save As… to save input data under a different file name.
- Exit to exit program EnSlope.

- Other entries include quick access to a history of recently-opened files.

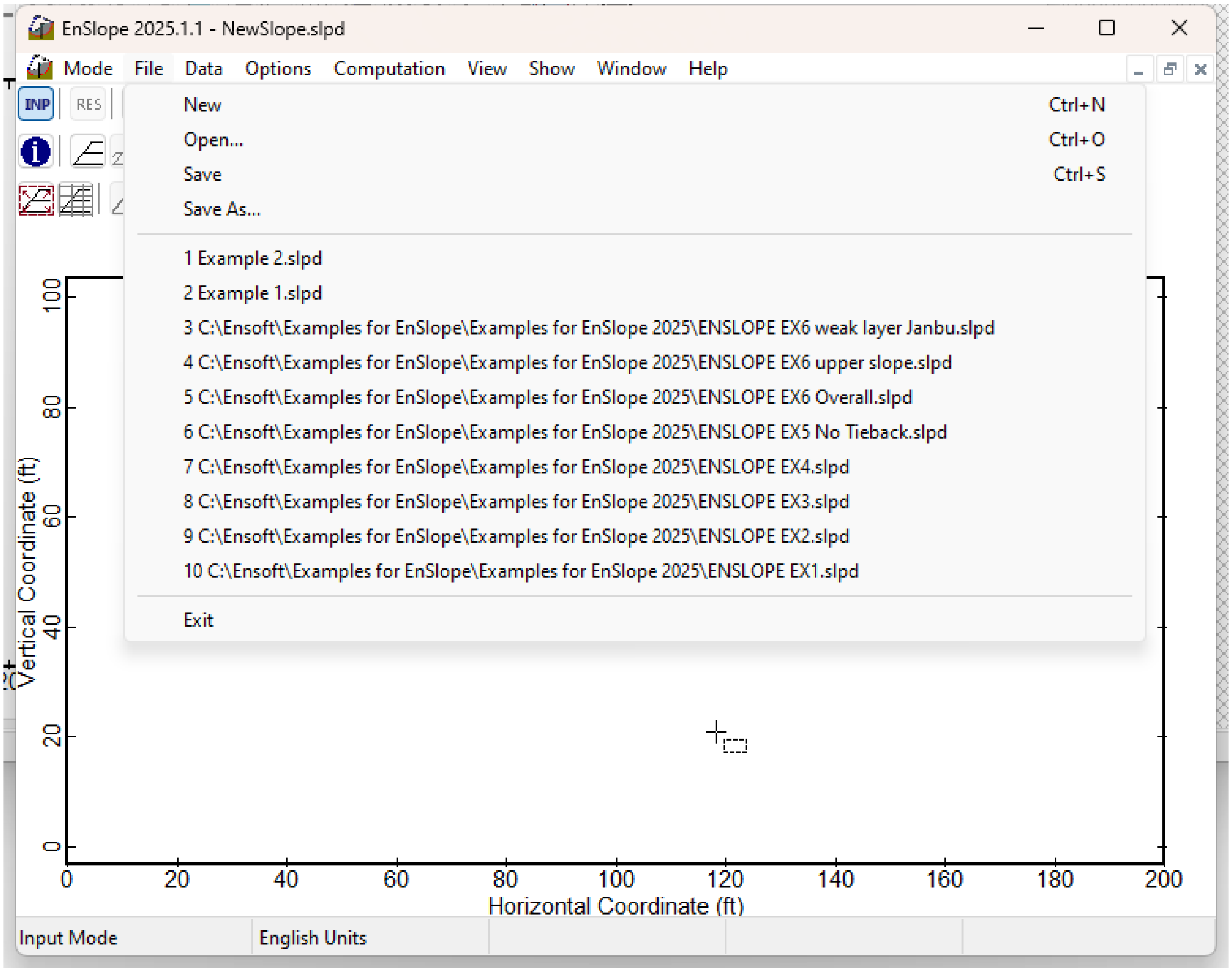


Figure 2.12 Options contained in the File menu

Several additional files are created in every new EnSlope run. A general description of these files is presented in Table 2.1. Every run of EnSlope generates four text files in the same drive and directory where the input-data file was saved or opened. Any of these files may be opened with standard text editors or word processing programs.

File Name Extension	Usage Description	File Format	Example Files
**.slpd*	Input-data file	Text file	*example1.slpd* *example2.slpd*
**.slpi*	Source data file	Text file	*example1.slpi* *example2.slpi*
**.slpo*	Output-data file	Text file	*example1.slpo* *example2.slpo*
**.slpp*	Plot-data file	Text file	*example1.slpp* *example2.slpp*
**.slpr*	Processor-data file	Text file	*example1.slpr* *example2.slpr*
**.slpg*	Parameter-data file	Text file	*example1.slpg* *example2.slpg*

Table 2.1 Files created in EnSlope runs

2.2.4 Data Menu

The Data menu contains several choices of submenus, as shown in Figure 2.13. The choices are listed below, along with a general description of their use. Some options will be enabled as the user enters the project information.

Model Extends .... to enter the general dimensions of the model to be defined.

Grid Settings .. .. to enter the grid spacing.

Title .... to enter a single line of text with a general description for the project.

Boundary Segments ..... to enter the boundary segments used to define the surface boundaries of the model. The entry will also define the coordinates of each profile line for the geometry of the slope and the soil strata.

Piezometric Surfaces ... this submenu is used to input data for the piezometric surface. This is an optional input.

Soil Properties .... to enter appropriate properties of each soil layer, such as undrained shear strength, or angle of internal friction, and other soil properties may be entered. The input for this submenu is also to identify the soil types exhibiting anisotropic properties of shear strength. This is an optional input that is disabled, as a default, for all new files.

Surcharge Loading....... this submenu is used to input the data for surface loads. This is an optional input.

Earthquake Loading...... this submenu is used to input the data for earthquake loads. This is an optional input.

Trial Surface Limits .... this submenu is used to input data for confining critical surfaces within certain zones. This is an optional input.

Tiebacks ....this submenu is used to input data for tieback or concentrated loads. This is an optional input.

Reinforcement Layers .. Program EnSlope 2025 allows the user to analyze embankments constructed on soft ground reinforced with one or more layers of reinforcement. The user enters the location of each reinforcement layer, the distribution of available axial and shear forces, and the direction in which the force acts.

Method of Analysis........the submenus under this menu are as follows: *Janbu's Method* allows the use of Janbu's procedures for the stability analysis of the failure surface; *Bishop's Method* allows the of use Bishop's procedures for the stability analysis of the failure surface; *Spencer's Method* allows the of use Spencer's procedures for the stability analysis of the failure surface.

Failure Surface Search ....the submenu under this menu are as follows: *User-Defined Failure Surface* allows the user to specify the predefined or a given failure surface; *Generate Circular Failure Surface Search* allows the use of procedures to generate circular failure surfaces; *Generate Irregular Failure Surface Search* allows the use of procedures to generate irregular failure surfaces; *Generate Block Failure Surface Search* allows the use of procedures to generate block failure surfaces.

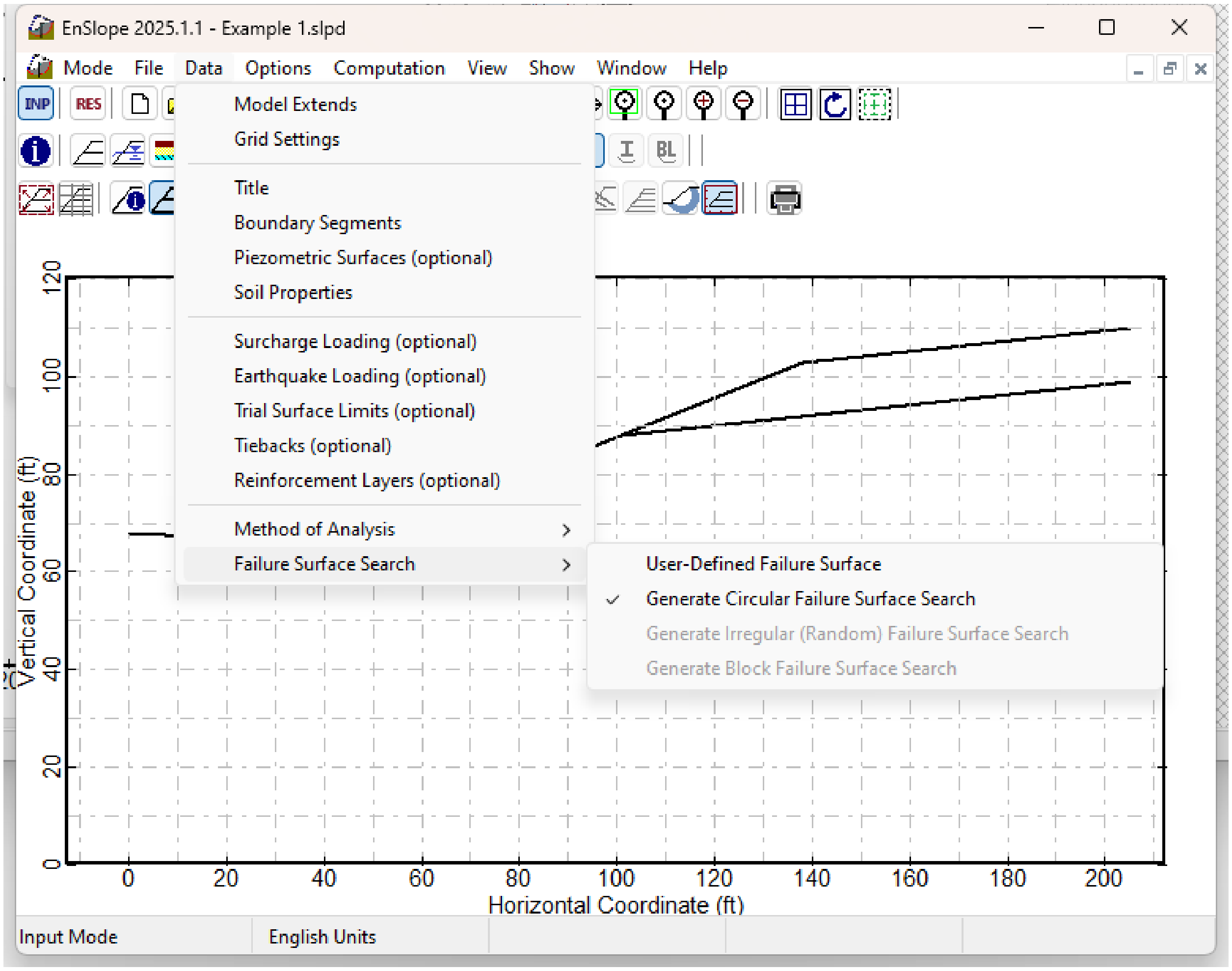


Figure 2.13 Options contained in the Data menu

2.2.5 Options Menu

The Options menu is provided for the control of program variables and preferences. The listing of menu options is shown in Figure 2.14 and the different submenu choices are briefly described below. The user may select any of the options without concern for the sequential order.

Units ....the user may select either English Units (using lbs and feet) or S.I. Units (using kN and meters). English units are enabled, as a default, for all new runs. The user may change the system of units as many times as desired and values that were previously input will be automatically converted by the program to the new selection of units.

Control Options ....the user may select parameters for convergence criteria and layer reinforcement method.

Text Editor ......the observation of text files associated with EnSlope (input, output, or processor notes) is done using the text editor that is here selected by the user. The user should input in this box the complete path and command line for the preferred text editor or word processor that will be used to examine and print the input, output, and processor plain text files created by the program. As a default, the command line *c:\windows\notepad.exe* is used to operate the standard text editor Microsoft Notepad that is normally included with all Windows installations.

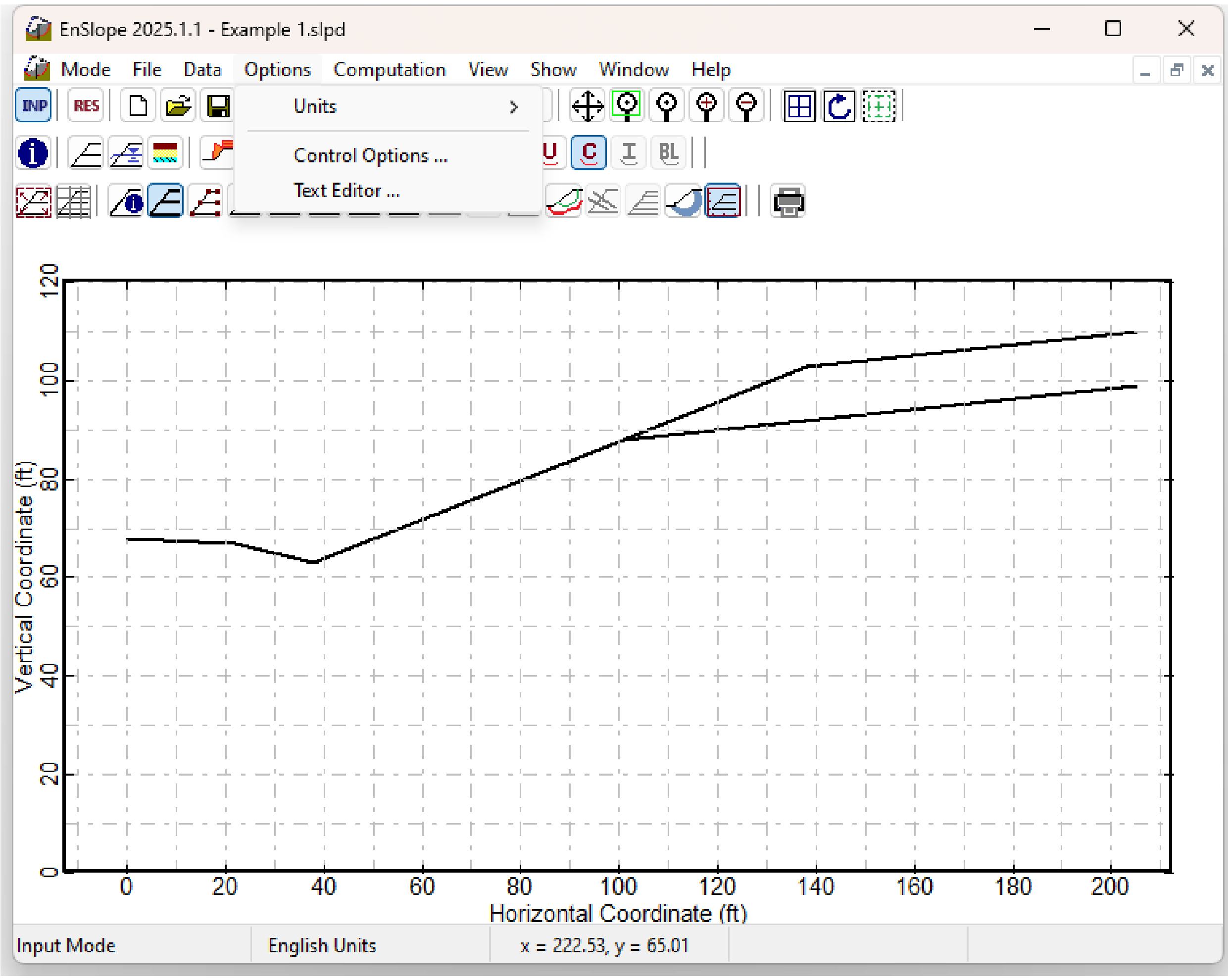


Figure 2.14 Options contained in the Options menu

2.2.6 Computation Menu

The Computation menu is provided to run the analytical computations after all data are entered and saved. After the computation is executed successfully this menu also provides options for the reviews of plain-text input data, notes produced during computation, and output data. It also provides an option for the graphical observation of the modeled pile and soil layers. Submenu choices, shown in Figure 2.15, are briefly described below.

Run Analysis .. this option is chosen to run the analytical computations. This option should be selected after all data have been entered and saved.

View Input Text .... this option calls the chosen Text Editor (selected under Options/Text Editor) to observe the analytical input data in plain-text format. The option becomes available after the input data has been saved to disk, or when opening an existing input-data file.

View Processor-Run Notes this option calls the chosen Text Editor (selected under Options/Text Editor) to observe, format, and/or print the notes provided during processing. The option becomes available (or modified) after a run attempt has been made. The user is encouraged to read the processor-run notes if the program is not running successfully. The processor-run notes may provide the user with some additional information about possible causes of the problem.

View Output Text .... this option calls the chosen Text Editor (selected under Options/Text Editor) to observe, format, and/or print the analytical-output data. The option becomes available only after a successful run has been made. Certain output files may be too large for the Microsoft Notepad editor, so other text editors would have to be used (Microsoft Word Pad should be able to open most text files).

Check Analysis Status ... this submenu option is used to view the status of an analysis previously run for the model.

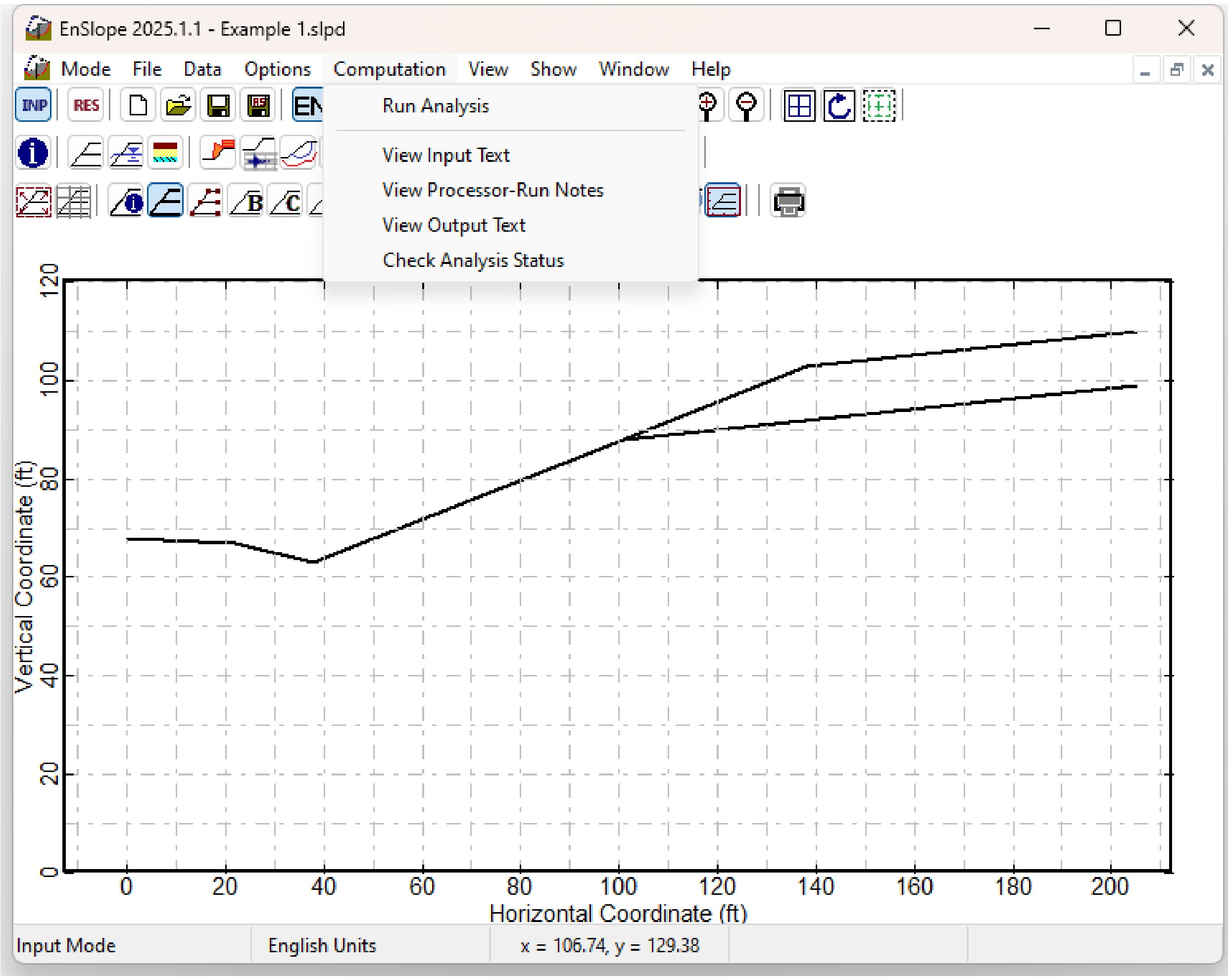


Figure 2.15 Options contained in the Computation menu

2.2.7 View Menu

The View menu is used to select the mode for showing the model and allow transformations of the model view. The view menu changes whether the Graphics Utility window is open or not. Listings of view options are shown in Figure 2.16 and Figure 2.17. The different submenu choices are briefly described below.

Panning...........this option is available if the Graphics utility window is opened. This option allows the user to translate the image displayed as the mouse is dragged.

Zoom Window ....this option is available if the Graphics utility window is opened. This option allows the user to define a window for a closer view.

Zooming..........this option is available if the Graphics utility window is opened. This option allows the user to zoom in (moving the mouse up) or out (moving the mouse down) as the mouse is dragged.

Zoom In...........this option is available if the Graphics utility window is opened. This option allows the user to display a closer view.

Zoom Out........this option is available if the Graphics utility window is opened. This option allows the user to display a wider view.

Restart View ..this option is available if the Graphics utility window is opened. This option allows the user to display the model in full.

Refresh View .this option is available if the Graphics utility window is opened. This option allows the user to redraw the model. This option is useful after the input data has been changed.

Pause Input Entries ......this option is available if the Graphics utility window is opened. This option allows the user to pause the entries used with the mouse movement to make some transformations like panning or zooming. Click on this option again to return to the entry mode.

Select Boundary Lines..this option is available if the Graphics utility window is opened. This option is enabled only while defining soil properties. This option allows the selection of Boundary Lines to be assigned to soil types.

Select Boundary Segments this option is available if the Graphics utility window is opened. This option is enabled only while defining tiebacks. This option allows the selection of Boundary Segments to be assigned where the tieback is located.

Select Piezometric Surfaces this option is available if the Graphics utility window is opened. This option is enabled only while defining soil properties. This option allows the selection of a Piezometric Surface to be assigned to a soil type.

Mode Toolbar.this option is available if the Graphics utility window is opened. This option allows the user to show or hide the tool buttons associated with the Mode menu.

File Toolbar ....this option is available if the Graphics utility window is opened. This option allows the user to show or hide the tool buttons associated with the File menu.

Options Toolbar.............this option is available if the Graphics utility window is opened. This option allows the user to show or hide the tool buttons associated with the Options menu.

Computation Toolbar ....this option is available if the Graphics utility window is opened. This option allows the user to show or hide the tool buttons associated with the Computation menu.

View Toolbar ..this option is available if the Graphics utility window is opened. This option allows the user to show or hide the tool buttons associated with the View menu.

Data Toolbar ..this option is available if the Graphics utility window is opened. This option allows the user to show or hide the tool buttons associated with the Data menu.

Show Toolbar.this option is available if the Graphics utility window is opened. This option allows the user to show or hide the tool buttons associated with the Show menu.

Show All Toolbars ....this option is available if the Graphics utility window is opened. This option allows the user to show all the toolbars.

Hide All Toolbars .... this option is available if the Graphics utility window is opened. This option allows the user to hide all the toolbars.

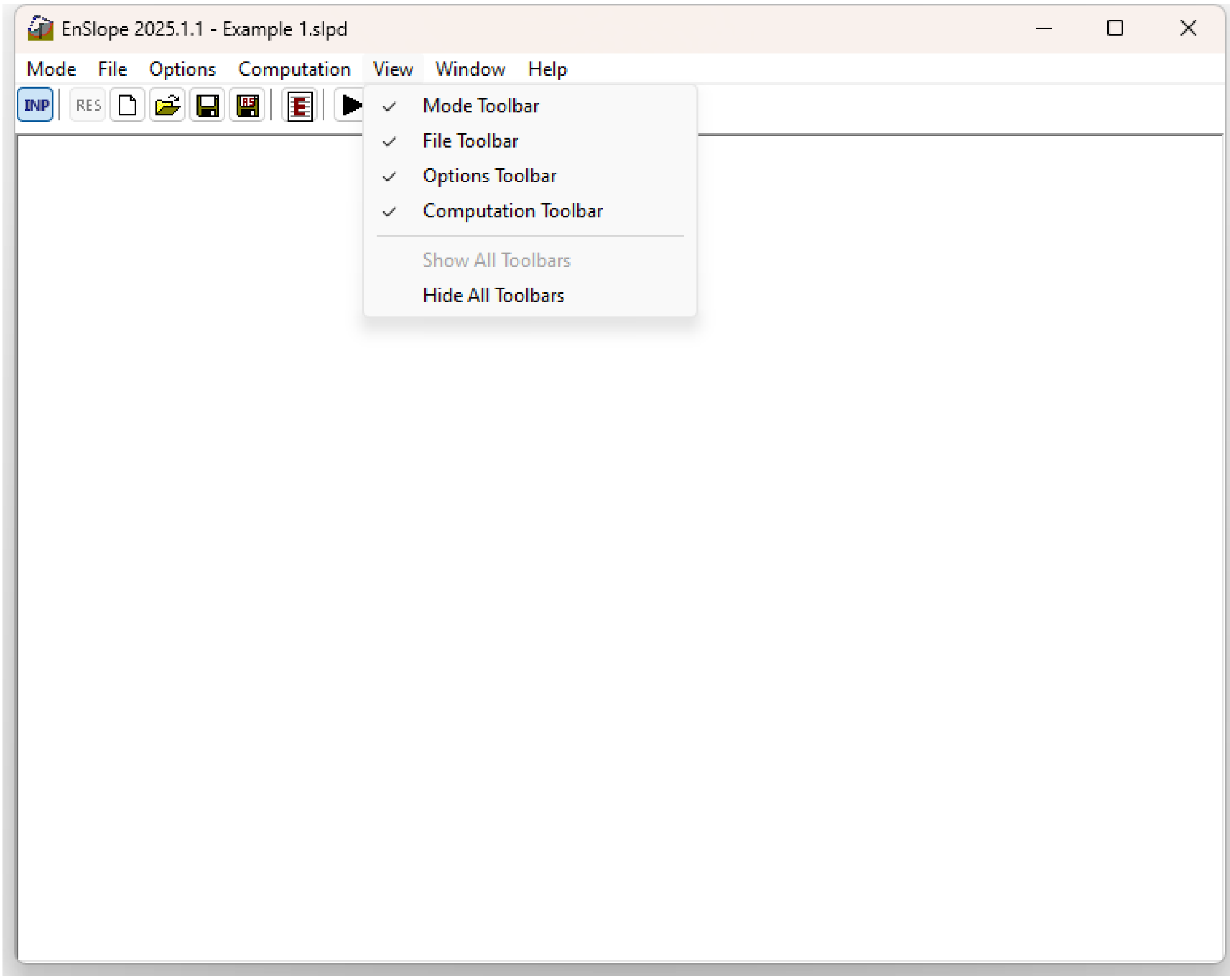


Figure 2.16 Options contained in the View menu

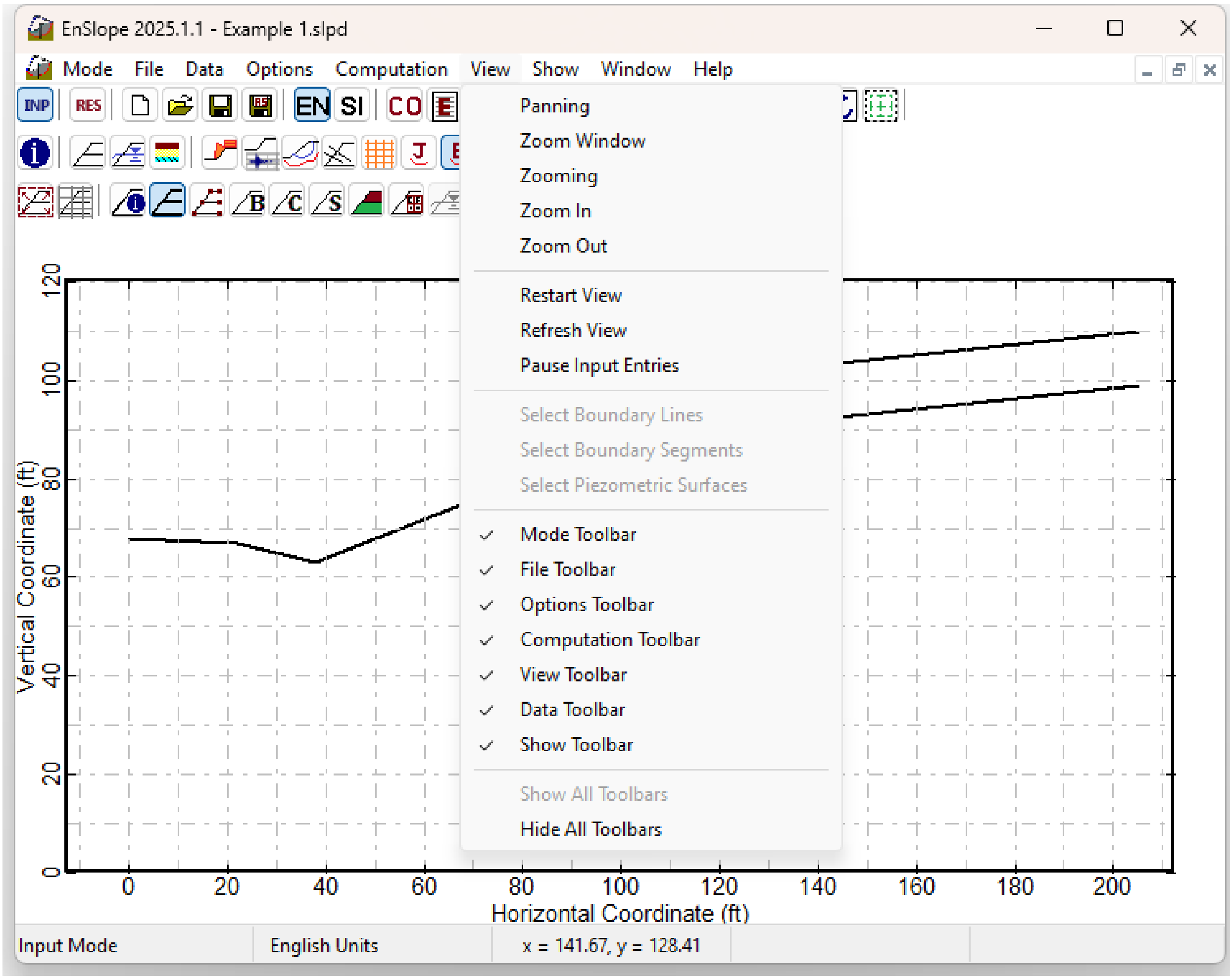


Figure 2.17 Options contained in the View menu, if Graphics Utility window is opened

2.2.8 Show Menu

The Show menu is used to select the mode for showing the model and allow transformations of the model view. The Show menu is available when the Graphics Utility window is open. The Graphics Utility Window is used to observe plots of input data and output data provided by a successful program run. Options for the observation of output results under this menu are only enabled after a successful run has been made. Even after performing successful runs, some options may still be disabled since the amount of output data depends on specifications provided in the input file of each program run. Submenu choices, shown in Figure 2.18 and Figure 2.19, are briefly described below:

Most of the graphical representation of input data may be shown on the screen for verification by checking one or more of the following options.

Model Extends .... to enter the general dimensions of the model to be defined.

Grid Settings ..to enter the grid spacing.

Title..................shows title of the project on top of the chart.

Boundary Lines.............show user-specified boundary lines of the slope geometry.

Boundary Nodes...........show nodes of the user-specified lines of the slope geometry.

Boundary Line Numbers .... show the boundary segment of each line of the slope geometry.

Boundary Coords …. ....show coordinates of each point of the boundary lines entered by the user.

Soil Layer Numbers ......show the soil layer number associated to each boundary line.

Shade Soil Layers…....show color on each soil layer for distinction.

Soil Parameters…........show a table with the values of parameters for each soil layer.

Piezometric Surfaces....show the piezometric surfaces defined by the user.

Surface Pressures.........show surcharge loads or other surface pressure that were entered by the user.

Earthquake Loading......show the earthquake loading that was entered by the user.

Search Limits .show user-specified trial surface limits if defined.

Tiebacks... ......show locations of user-entered tiebacks.

Reinforcement Lines.....show the layout of the reinforcement lines defined by the user.

Search Region….........show an approximate zone for the search region defined by the user.

Scale…. ....show horizontal and vertical scale of the model.

Show Options…............show an option to allow scaling for display of surfaces pressures.

Print…. ....allows the printout of the current view of the model.

The computed results can be shown on the screen for graphical representation. The options for graphics as listed below.

Solution Information......shows the factor of safety and center of the most critical failure surface.

Critical Slip Surface…...show the most critical slip surface found by the program.

Critical Slip Slices…......show slices for the most critical slip surface found by the program.

Critical Slip Line of Thrust. show the line of thrust for the most critical slip surface found by the program.

10 Slip Surfaces… ....show the 10 most-critical slip surfaces searched by the program.

All Trial Surfaces…. ......show all the trial slip failure surfaces generated by the program.

Total Stresses…...........show the distribution of total stresses on the slip failure surface.

Effective Stresses…......show the distribution of effective stresses (if available) on the slip failure surface.

Shear Stresses…. ....show the distribution of shear stresses on the slip failure surface.

Pore Water Pressures ..show the distribution of pore water pressure on the slip failure surface.

Contour Legend…......... show an option to allow changing of default parameters if all trial surfaces are shown in the view.

Show Options…............ show an option to allow scaling for display of total stresses, effective stresses, shear, interslice forces and pore water pressures.

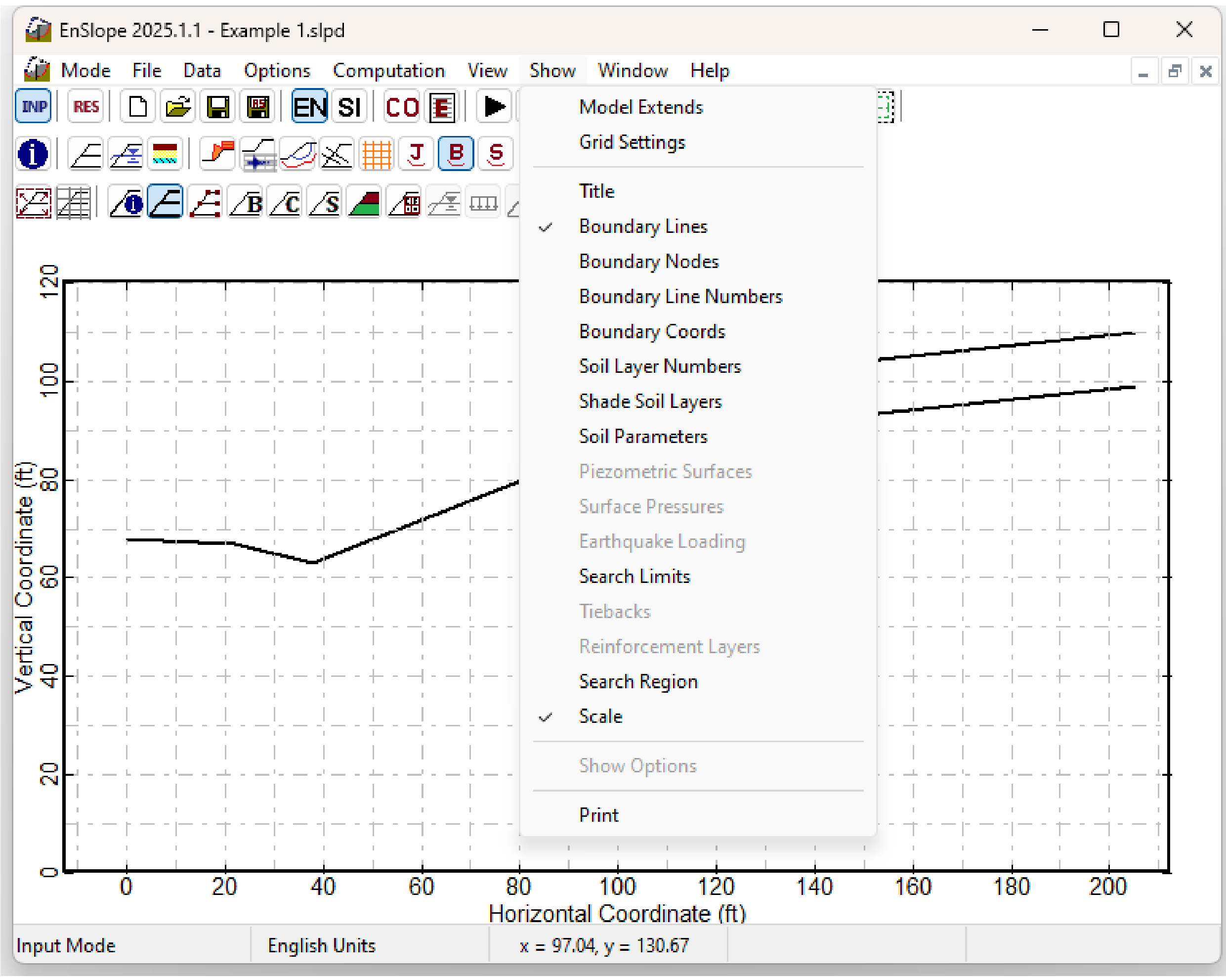


Figure 2.18 Options contained in the Show menu.

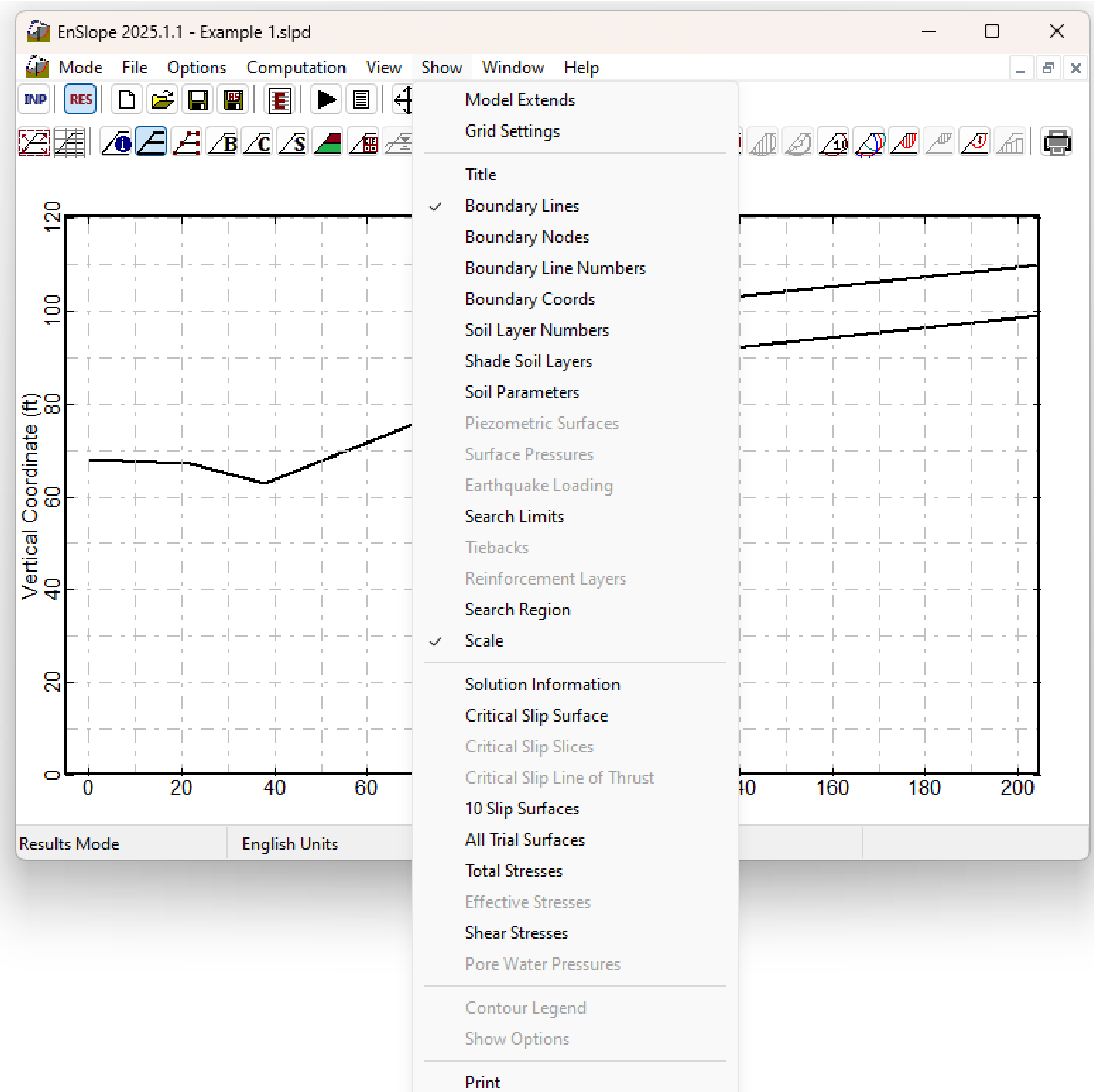


Figure 2.19 Options contained in the Show menu if results are available.

2.2.9 Window Menu

The Window menu provides two standard functions for organizing opened windows and/or minimized window icons. Submenu options, shown in Figure 2.20, are briefly described below.

Cascade..........this option organizes all open-windowed menus so that all become visible with their tops cascading from the top left portion of the screen.

Arrange Icons. ....this option organizes the icons of all minimized windowed menus so that all become visible and aligned at the bottom portion of the screen.

Other entries under the Window menu are names of any open windows or plot file, that the user may select to navigate between open windows.

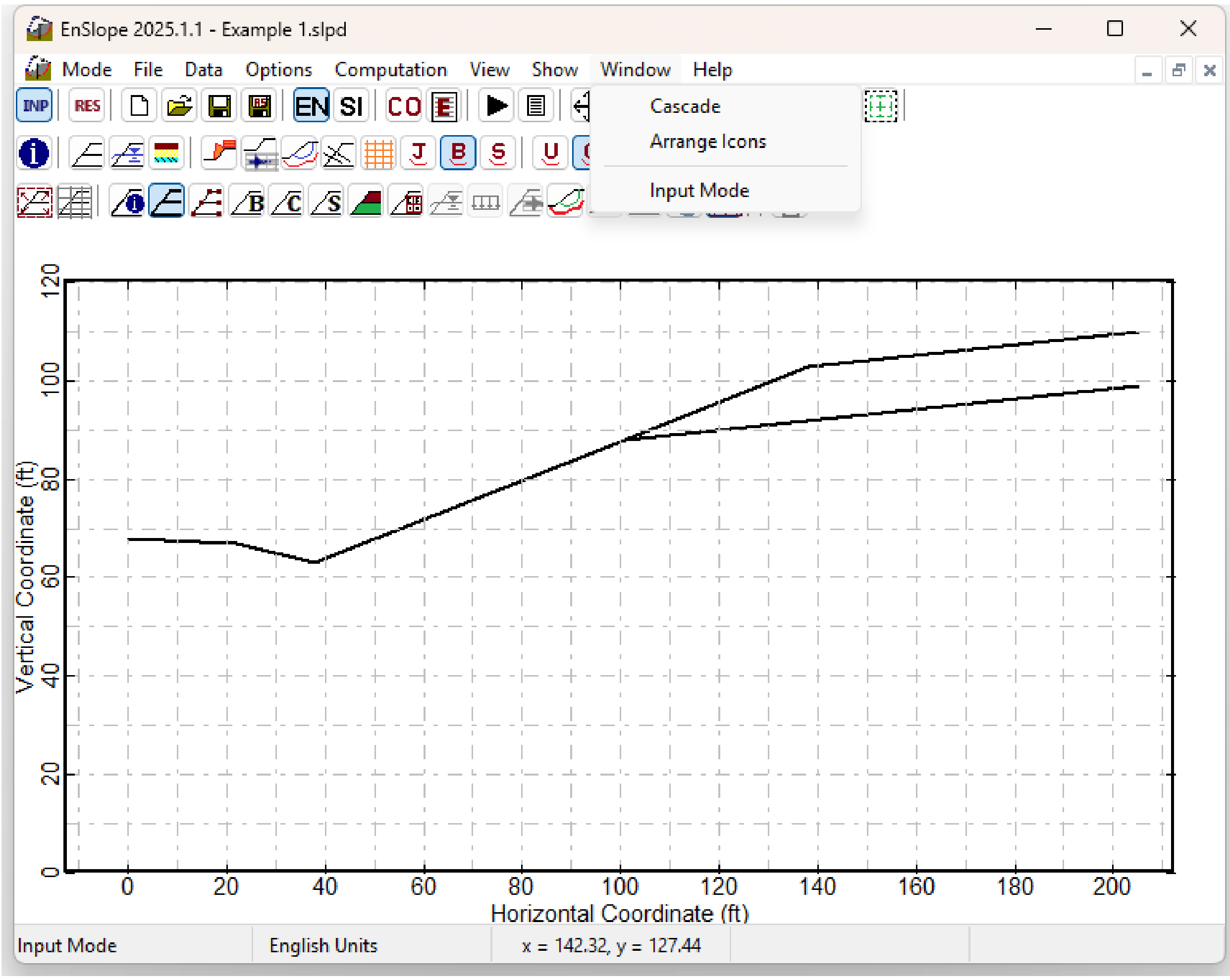


Figure 2.20 Cascade option from the Window menu

2.2.10 Help Menu

The Help menu provides an online help reference on topics such as: using the program, entering data, information about variables used in the program, and methods of analyses. Submenu options, shown in Figure 2.21, are briefly described below. The menu may be accessed at any time while in EnSlope.

User's Manual .... this selection calls the installed version of Adobe Acrobat or Acrobat Reader to open the User's Manual. This document is formatted as an Adobe PDF file.

Technical Manual .... this selection calls the viewer of the Technical Manual. This document is formatted as an Adobe PDF file.

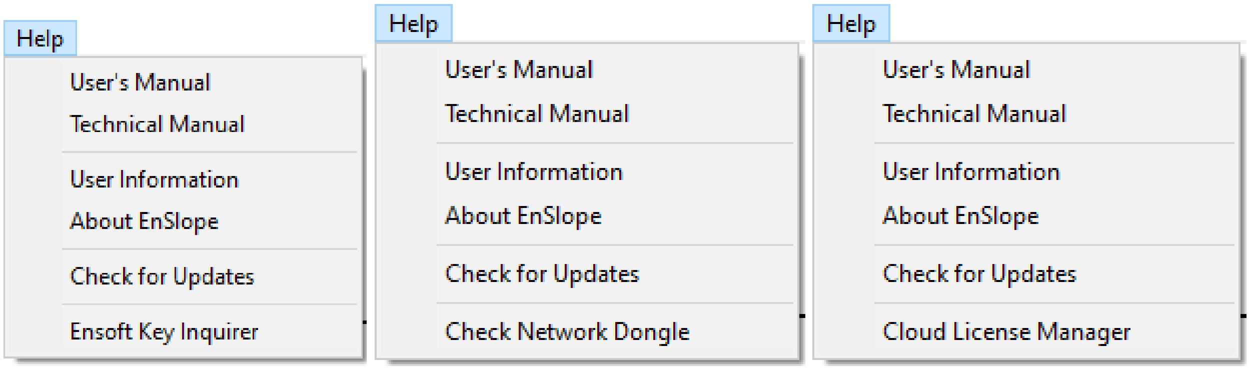
About .... this provides a screen describing the program version, date, maintenance expiration date, USB serial number, and methods for accessing technical support.

Check for Updates .... starts the default Internet browser and sends the user to a page that describes information about the user's license (release and maintenance expiration date) as well as the latest release that is available for downloading at the Ensoft site. Users may only run in full mode maintenance updates that were released before the expiration date of the user's license.

Ensoft Key Inquirer........ this selection is only available for single-user licenses (not available in local network licenses). This utility allows the user to check information contained in the USB Key that is attached to the computer in use. With this utility the user can see the following information: dongle serial number and expiration date, licensed program names and type of licenses, maintenance expiration date of each software license, licensed company name, allowed IP subnets. This utility is installed in the selected installation directory with the following filename: *ensoft_key_inquirer_v5.exe* (may change with time).

Check Network Dongle. this selection is only available in client computers of local network licenses (not available in single-user licenses). This calls the utility that is used to check the licensing and to troubleshoot communications with a license manager (or software server). This utility is very useful in case of problems in clients while trying to run the licensed software. This utility is installed in the selected installation directory with the following filename: *CheckNetworkDongle_ipv_511.exe* (may change with time).

Check Network Dongle. this selection is only available on cloud subscription installations of the software product (it is not available for users with USB Key based installations, such as single-user or network licenses). This menu provides access to information and some management of the cloud subscriptions licenses.



a. Single-User License　　b. Client on Local Network License　　c. Cloud Subscription License

Figure 2.21　Help Menu

CHAPTER 3. References for Data Input

3.1 Introduction

The DATA menu consists of various input items for data entry. Users may select any of these items in any order, as sequential order is not required. Some input parameters are optional and can be skipped if they are not relevant to the problem at hand. However, certain items, such as boundary segments, soil layers, and search definitions, are always required. Input-data files created for EnSlope use a standard file-name extension in the format *.slpd (where * represents any allowable file name). All input-data files are standard text files and can be edited using any text editor or word-processing program. Users can click on any of these items to view them. Consistent units should be used throughout the data input.

EnSlope is compatible with any system of units that the user prefers for analysis. As long as consistent units of length and mass are used, the program will function without error. For example, one may use the following English or SI units:

Coordinates: feet (ft) or meters (m)

Unit Weights: pounds/cubic foot (pcf) or kilograms/cubic meter (kN/m^3)

Strength Intercept: pounds/square foot (psf) or kilograms/square meter (kN/m^2)

Pore Pressure: pounds/square foot (psf) or kilograms/square meter (kN/m^2)

Unit Weight of Water: 62.4 pcf or 9.8 kN/m^3

It is recommended (but not mandatory) that each slope to be analyzed is oriented left-facing and placed in the first quadrant, ensuring that all coordinates have positive values. It is essential to plot the problem's geometry to scale on a rectangular coordinate grid. While it is recommended (but not mandatory) to carefully choose the coordinate axes so that the entire problem is defined within the first quadrant, this helps the graphical aspects of the program function properly. For optimal resolution and accurate interpretation of output data, the coordinate limits should be set to encompass the problem geometry and allow for the analysis of the most critical failure surfaces. It is crucial to accommodate potential failure surfaces that develop beyond the toe or crest of the slope (Figure 3.1).

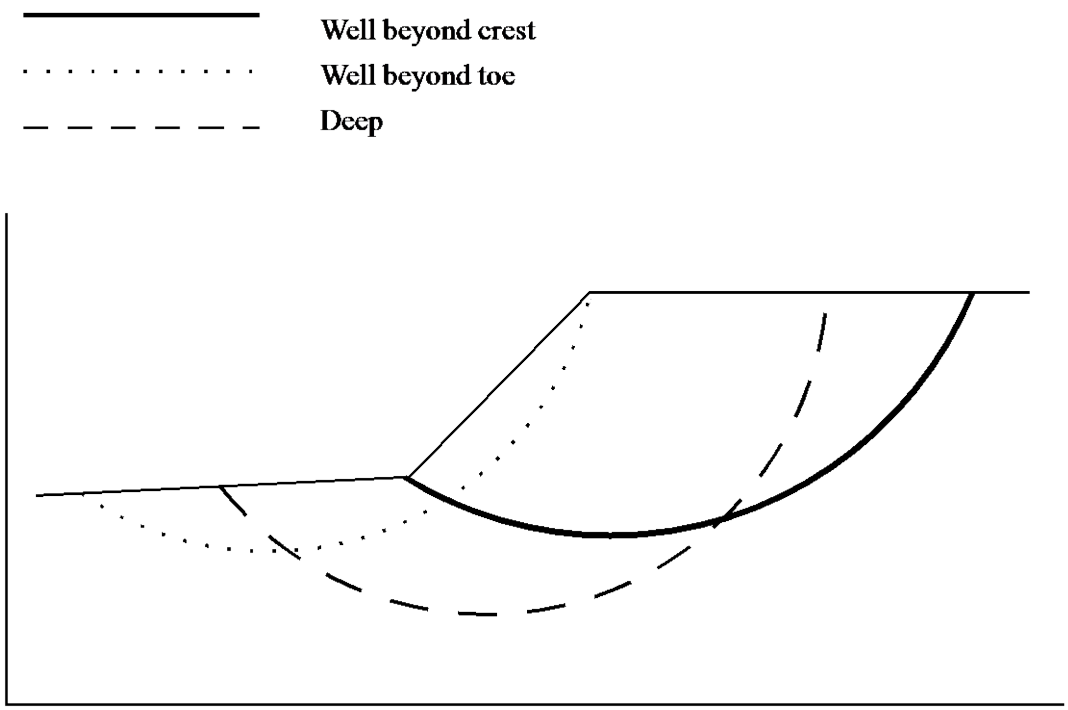


Figure 3.1 Example slope geometry and subsurface profile

3.2 File Menu

This menu contains options related to the management of input-data files and to exit the program. Input-data files created for EnSlope are provided with a standard file-name extension in the form of **filename*.slpd* (where **filename** represents any allowable file name). All input data files are standard text files and may be edited with any text editor or word-processing program.

3.2.1 File – New

Once the program is started, default values are used for certain operating parameters and a blank input-data file is created. Selecting New under the File menu resets all EnSlope variables to either default or blank values, as appropriate. This option should be selected when a new data file is desired to be created from a blank form. This menu option may also be accessed with the Ctrl+N keyboard combination.

3.2.2 File - Open

This is used to open a file that has been previously prepared and saved to disk. The File – Open window dialog, shown in Figure 3.2, is used to search and open an existing input-data file. By default, the file is initially searched in the directory where EnSlope was installed. Standard windows-navigation procedures may be used to locate the name and directory of the desired project file. This menu option may be accessed with the Ctrl+O keyboard combination.

Every analytical run of EnSlope produces several additional files (previously described in Table 2.1 of this manual). The name of the input-data file indicates the names of all related files produced by a successful program run (output, graphics, and processor text files). All the additional program files will be created in the same directory as the input data file. Input-data files that are partially completed may be saved and later opened for completion, run, and observation of results.

Opening some partially completed EnSlope input files or invalid data files (or files with incorrect data formats) may produce an information window reporting that an "invalid or incomplete" file is being opened (Figure 3.3). The user should click the OK button and all partial-input data that was previously prepared should become available.

The program allows users to read input-data files created for EnSlope (*,sld4, or *.sld file extensions) by selecting the drop-down arrow under the Files of type: option at the bottom of the File – Open window screen. The program will automatically convert the opened EnSlope input file to an EnSlope input file when the user saves the opened file.

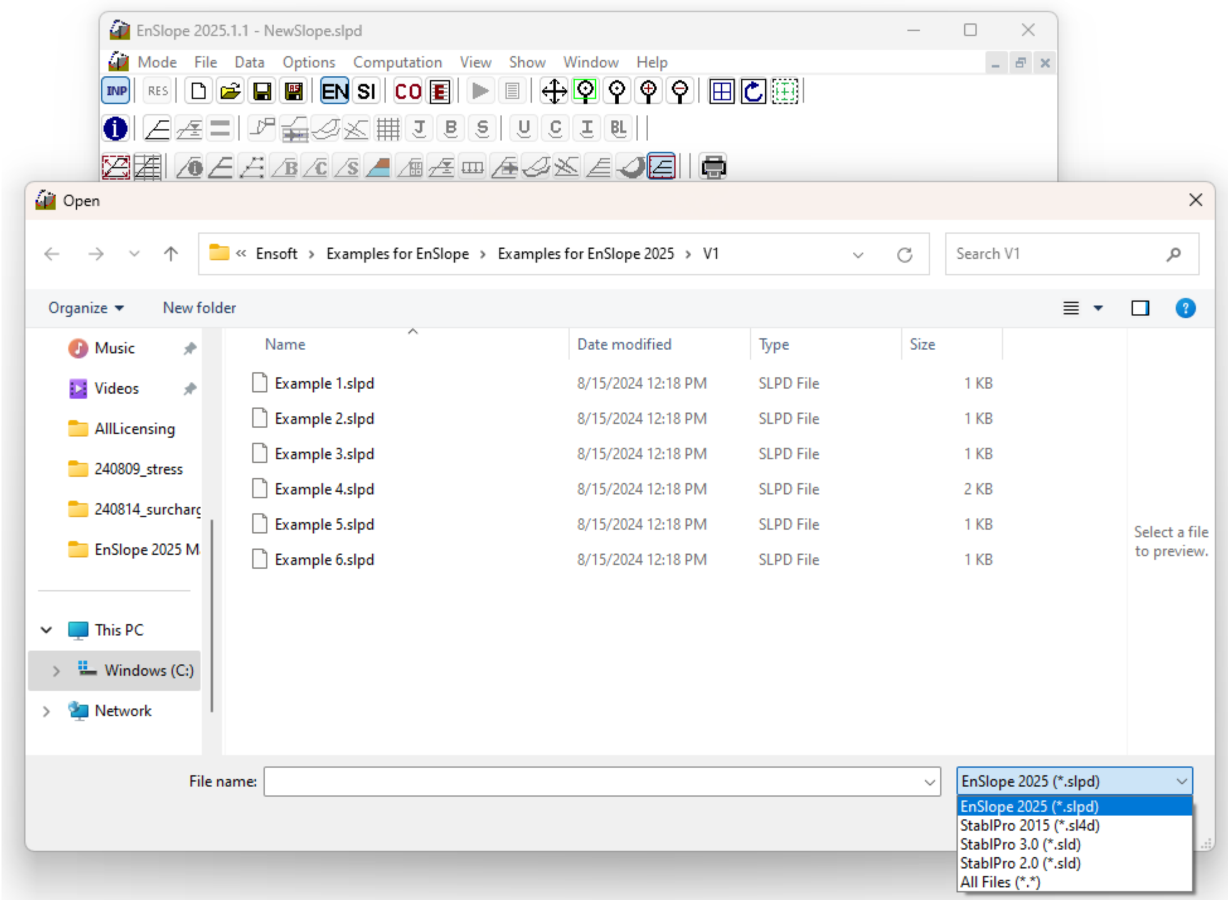


Figure 3.2 Window screen for the File – Open dialog

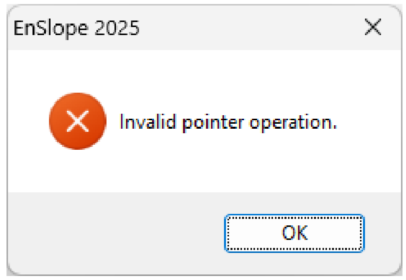


Figure 3.3   Sample message for incomplete or invalid file

3.2.3 File – Save

This option is used to save input data under the current file name. With this method of storing data to disk, any input data that was previously saved with the same file name is replaced with the current parameters. Input-data files should be saved every time before proceeding with runs for analytical computation. This menu option may also be accessed with the Ctrl+S keyboard combination.

3.2.4 File – Save As

This option allows the user to save any opened or new input data file under a different file name or different directory. Any input data file saved under an existing file name will replace the contents of the existing file.

3.2.5 File – Exit

This is selected to exit EnSlope. Any input-data file that was modified and not yet saved to disk will produce a confirmation window before exiting the program (see Figure 3.4).

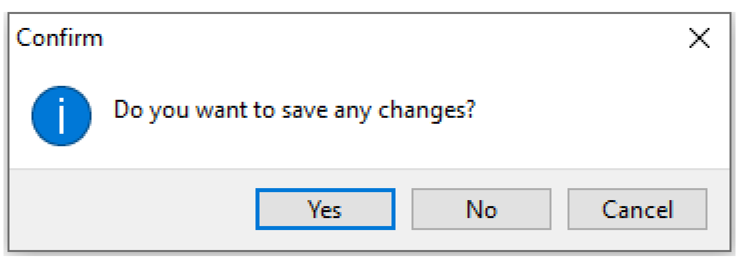


Figure 3.4   Message window advising that changes were not saved to disk.

3.3 Data Menu

The input of specific parameters for an application is controlled under options contained within this menu (shown in Figure 3.5). It is recommended that the user choose each submenu and enter parameters in a consecutive manner starting from the top.

Selecting or clicking any of the submenu choices contained in the Data menu produces various types of windows. As a reminder of standard commands of Microsoft Windows®, open windows may be closed by all or some of the following methods:

- clicking the OK button (if available), or
- clicking the X-box on the upper-right corner of the window, or
- pressing the "Ctrl+F4" keyboard combination, or
- double-clicking the EnSlope icon on the upper-left corner of the window, or
- clicking once on the EnSlope icon on the upper-left corner of the window and then choosing Close.

Open windows may optionally be left open on the screen. The selection of other menu options will then produce new windows on top of those that were previously left open.

Many sub-windows of the Data menu will show an Add Row, Insert Row, and/or Delete Row buttons. The Add Row button always adds new rows at the end after all existing rows. The Insert Row button always inserts a new row right after an existing row highlighted by the mouse. Clicking on the Delete Row button deletes the row where the cursor is located.

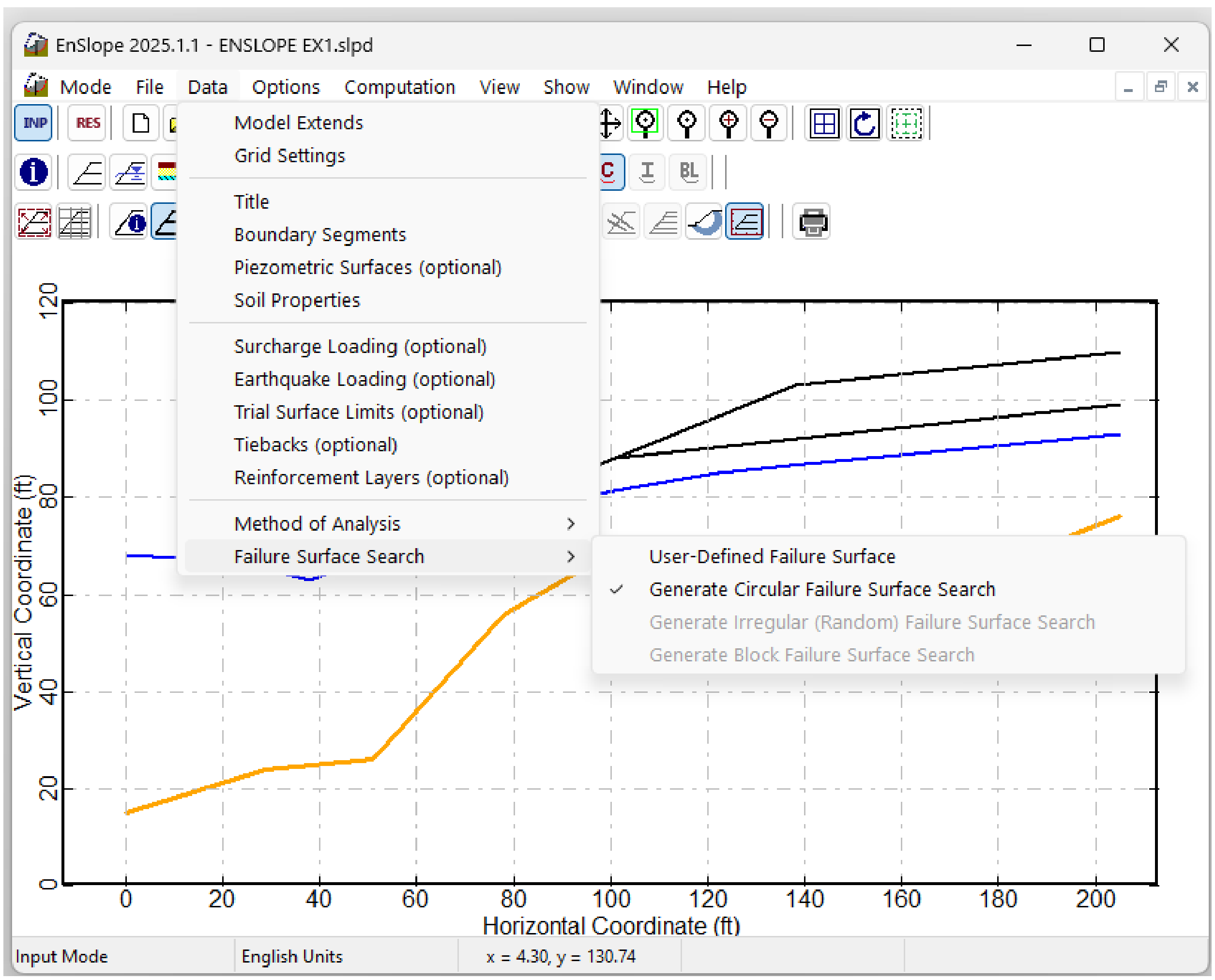


Figure 3.5 Options contained in the Data menu

3.3.1 Numeric Data Entries

Cells that require numeric data may accept entries of mathematical expressions in addition to simple numeric entries. Entering a mathematical expression works similarly to normal numeric data. The user types the expression that represents the data and presses the Return key to calculate the entered expression and to display the numeric result in the same cell.

Table 3.1 below shows the list of supported operations and constants. The order of operations follows the order in the list in Table 3.1. Note that implicit multiplication (e.g. 2(4+6)) is not supported (instead, use 2*(4+6) for the previous example).

	OPERATORS
Symbol	**Description**
()	Parenthesis (may be nested)
^	Exponentiation
*****	Multiplication
/	Division
+	Addition
-	Subtraction
-	Negation (same as subtraction)
	CONSTANTS
Symbol	**Value**
PI (or pi)	3.1415927
e (or E)	2.7182818

Table 3.1 Supported mathematical operations and constants

The two constants that are currently supported are PI and e. Implicit multiplications using constants are not supported (use 2*e instead of 2e). Negation of the constants PI or e is not allowed. For instance, instead of entering -PI the user must enter - (PI).

Scientific notation (e.g. 1.65e8 or 1.65e-8) may be used to input very large or very small numbers. After an expression is calculated, very large or very small numbers will be displayed using scientific notation.

3.3.2 Data – Model Extends

This option activates the Model Extends window, shown in Figure 3.6, where the user can enter the extends of the model. The user can also define the interval for scaling to be used for the model or let the program estimate it (default).

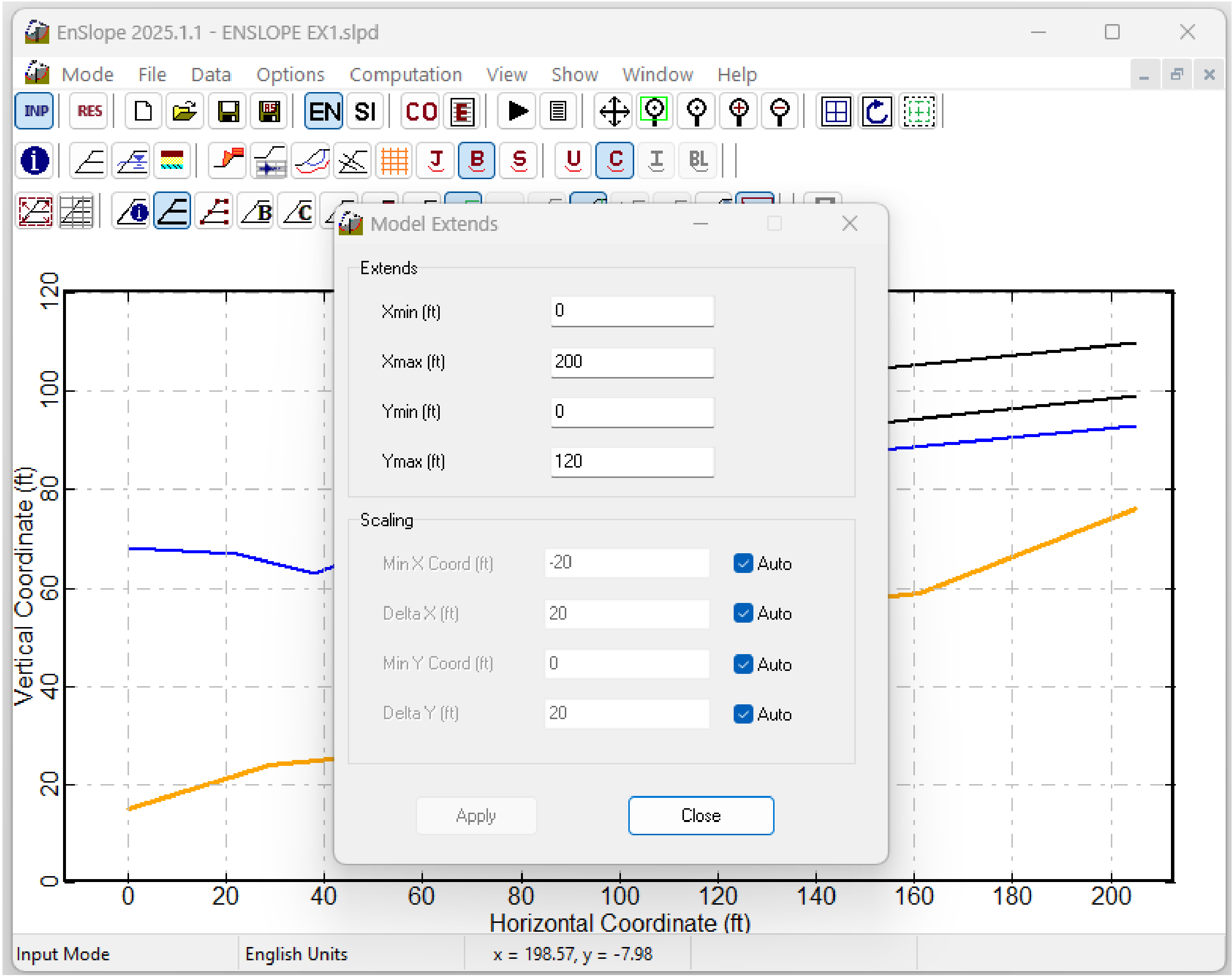


Figure 3.6 Window screen for sample Data – Model Extents

3.3.3 Data – Grid Settings

This option activates the Grid Settings window, shown in Figure 3.7, where the user can turn on/off displaying the grids in the model. The user can select and define the spacing for the horizontal (X) and vertical grids(Y).

In this window the user can define the use of incremental coordinates, while using this option as the user moves the mouse, it will update the coordinates based on the incremental spacing defined.

Also, in this window, the user can turn on/off the snapping to the grid, a point, or the middle of a line. To use the snapping option, the user should press the Ctrl key while moving the mouse over the desired point.

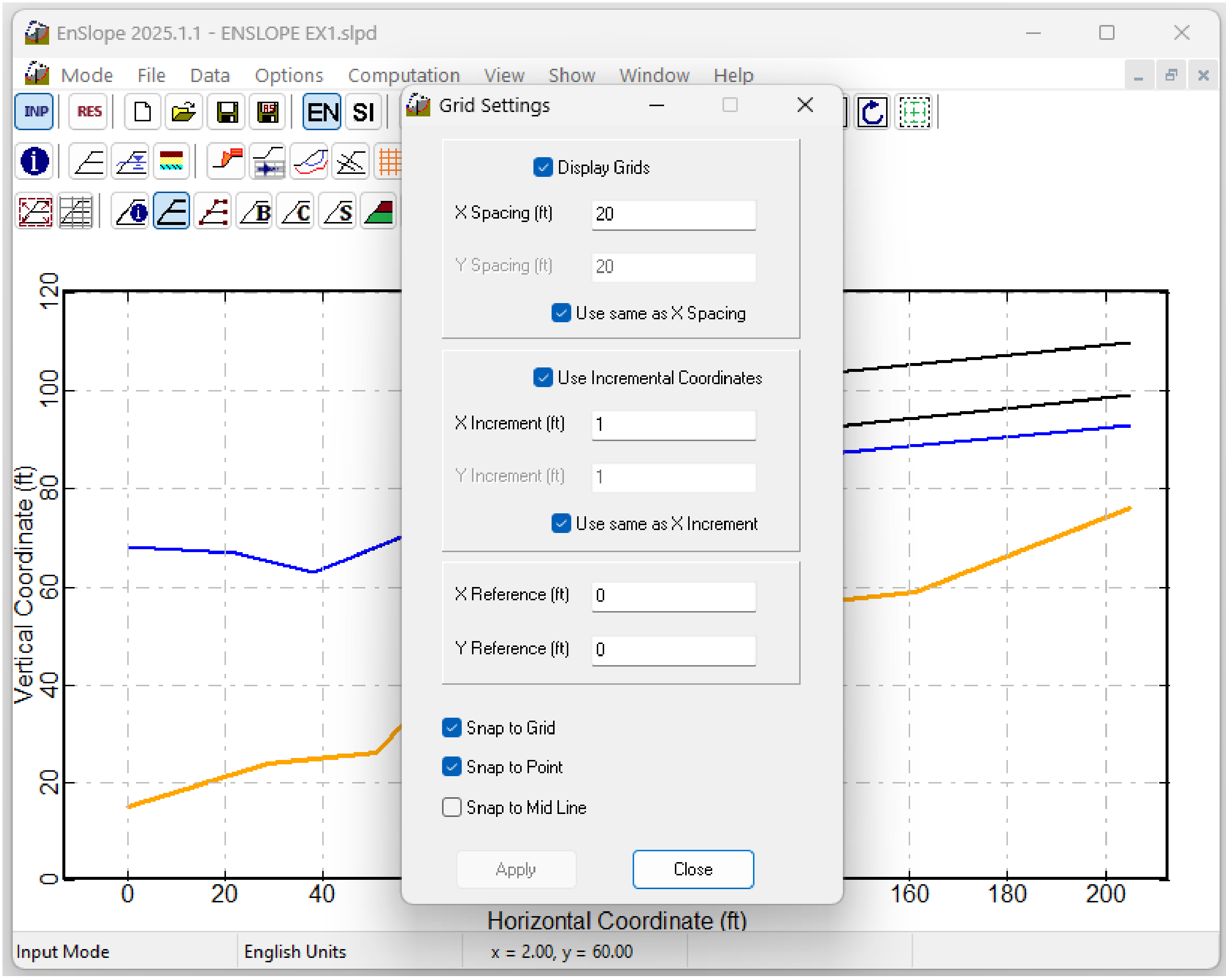


Figure 3.7 Window screen for sample Data – Grid Settings

3.3.4 Data – Title

This option activates the Title window as shown in Figure 3.8, where the user can enter a line of text containing a general description of the application problem. Any combination of characters may be entered in the text box to describe a particular application. The user input will be restrained automatically once the maximum length of text is reached. This is done to prevent the user from going beyond the maximum permissible length of characters allowed for the title line. Click on the Apply button, that will be enabled if changes are made to the title, to save the title changed without closing the window. Click on the Save and Close button to save the title and close the window. Click on the X box (upper right corner) to close the window without saving the changes.

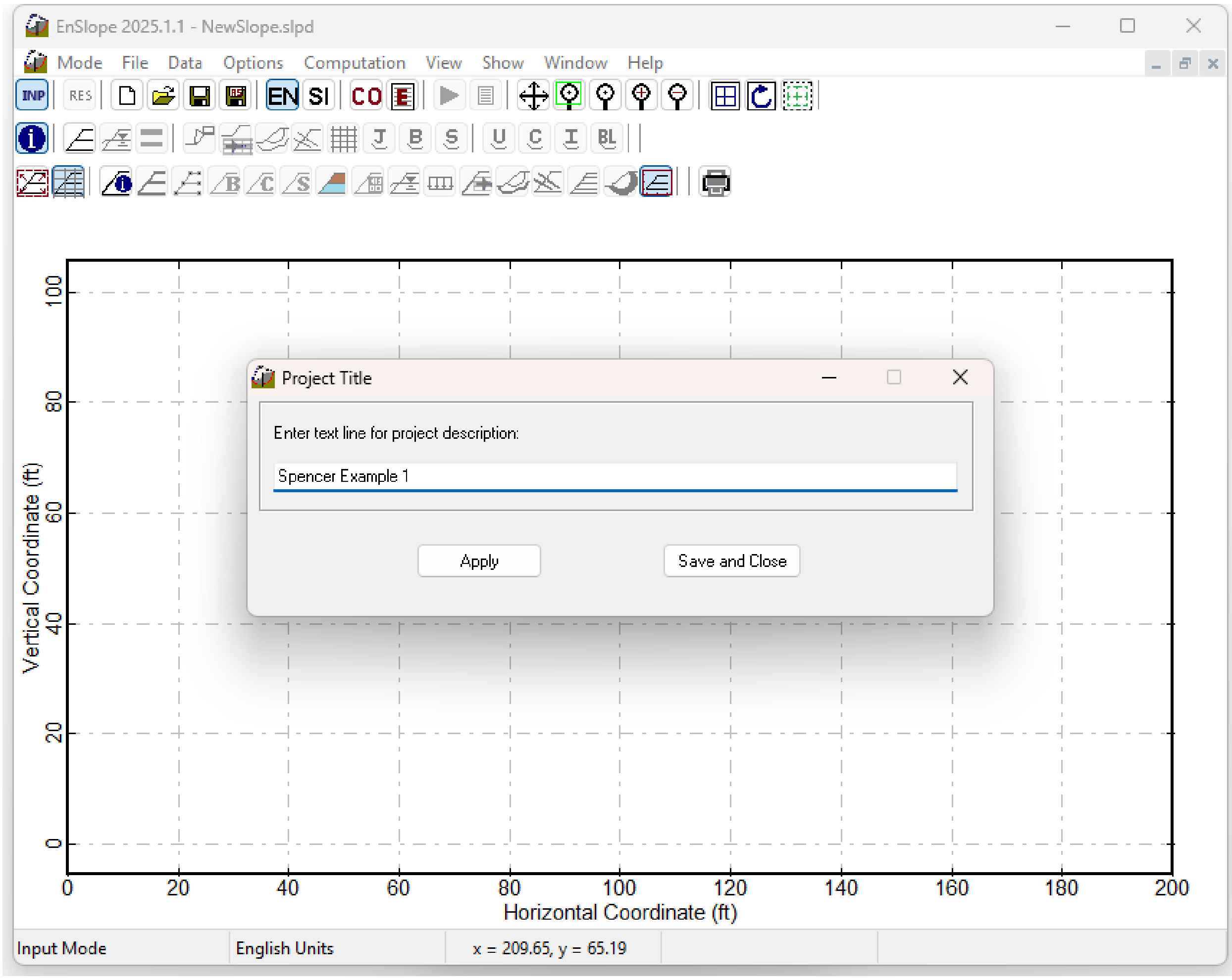


Figure 3.8 Window screen for sample Input Data – Title

3.3.5 Data – Boundary Segments

The window Boundary Segments will appear on the screen if Item – **Boundary Segments** of the Menu is selected (Figure 3.9). This window allows the user to enter interactively the coordinates of the boundary segments and/or edit boundary segments already defined.

Adding Segments

The adding segments option will show up automatically if no segment was defined before or after clicking on the “Add Segments” button at the left bottom corner of the Boundary Segments window.

There are three ways to enter a boundary segment: Inputting the node coordinates one by one using the mouse, entering the node coordinates one by one using the entry fields, and entering the nodes using a table. Also, the node coordinates can be entered as a combination of the three ways listed:

1. Using the mouse

To add a node, click the mouse left button. To end a segment, click the mouse right button.

2. Using the entry fields

To add a node, enter the coordinates of the node in the X Coord and Y Coord entry fields and press the Add Node button. To end a segment, press the End Segment button.

3. Using the table

Press on the Nodes Table button and the Nodes Table will show up (Figure 3.10). Please enter the X, and Y coordinates and the soil number associated with each node. Close the table using the X box on the top right corner to close the table and return to the Adding Boundary Segments window. To end the segment, press the End Segment button or click the right mouse button.

Notes

- As the nodes are entered, the current segment will be displayed in a gray color and the already-defined segments are displayed in a black color as displayed in Figure 3.9.
- After adding a node, the new node number will be displayed in the Node Number field.
- After completing a segment, the new segment number will be displayed in the Segment Number field.
- As the mouse moves, the coordinates are displayed in the status bar.

To cancel the current entries on the segment, please click on the Cancel Segment button, then a prompt will appear to confirm the cancelation process (Figure 3.11). Click on Yes to confirm the cancelation; otherwise, click on No to continue defining the current segment.

Click on Close to close the window Adding Boundary Segments. If the current segment has not been completed, then a prompt will appear indicating that the current changes have not been completed (Figure 3.12). Click on Yes to confirm losing the latest entries; otherwise, click on No to continue defining the current segment.

By checking on the option Show Rel. Figs. The window will display a figure related to the definition of boundary segments (Figure 3.13).

It should be noted that the slope to be analyzed is made left-facing as shown on the screen and placed in a first quadrant position so that all coordinates will have positive values. The ground surface boundaries are numbered first, from left to right consecutively, starting with “1”. All subsurface boundaries are then numbered in any manner as long as no boundary lies below another having a higher number.

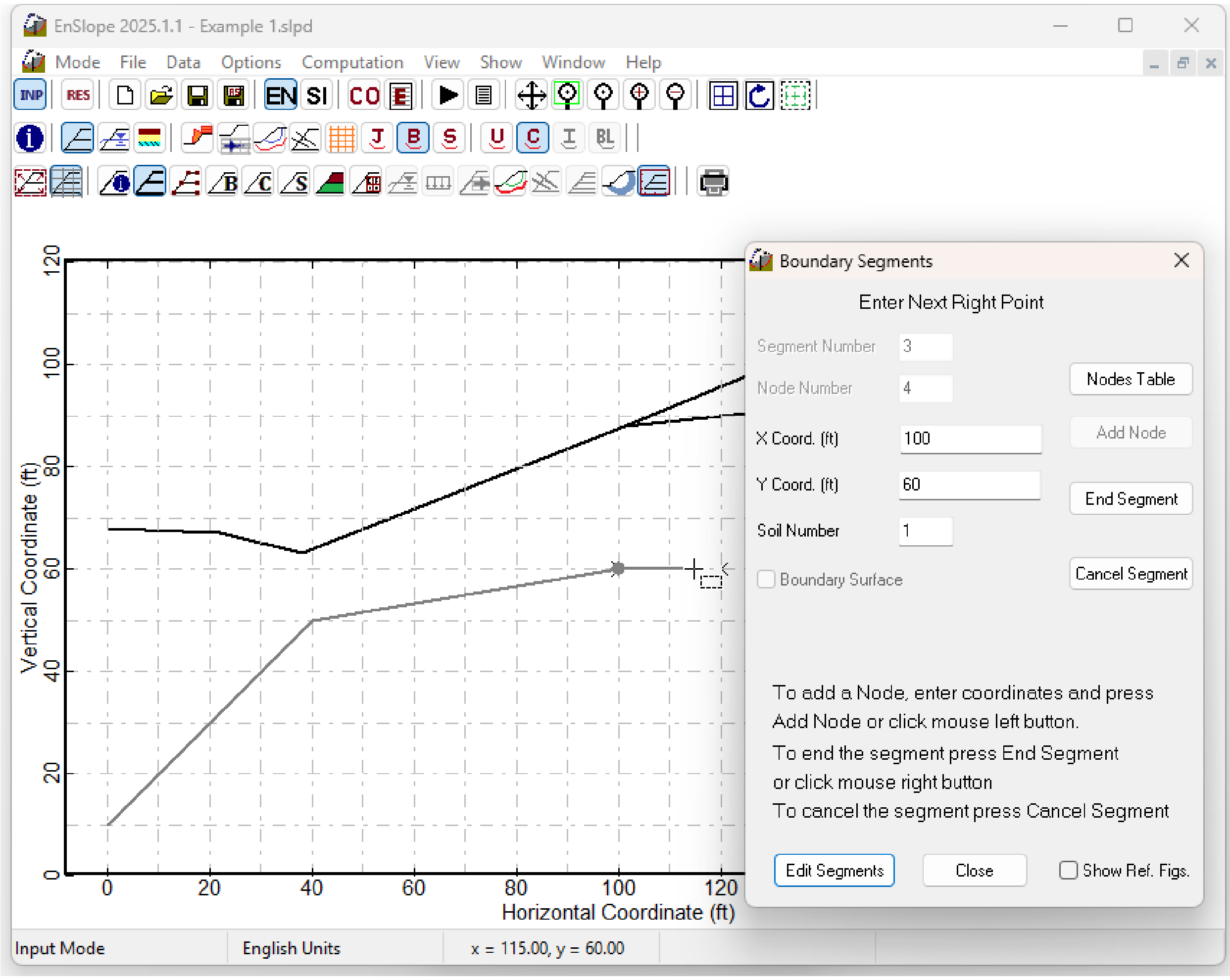
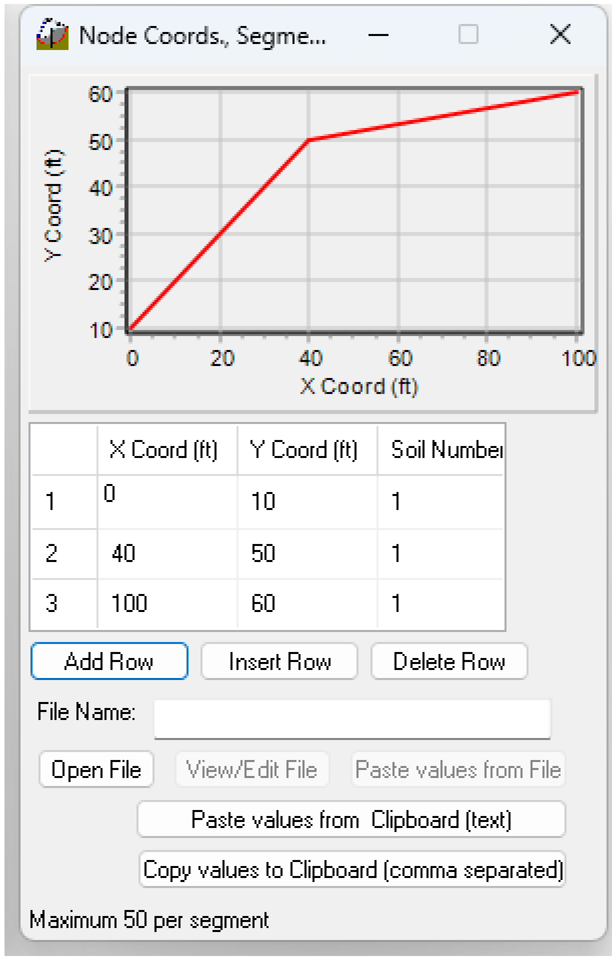


Figure 3.9 Window screen for sample Input Data –Boundary Segments



	X Coord (ft)	Y Coord (ft)	Soil Number
1	0	10	1
2	40	50	1
3	100	60	1

Figure 3.10 Window screen for sample Data – Boundary Segments – Nodes Table

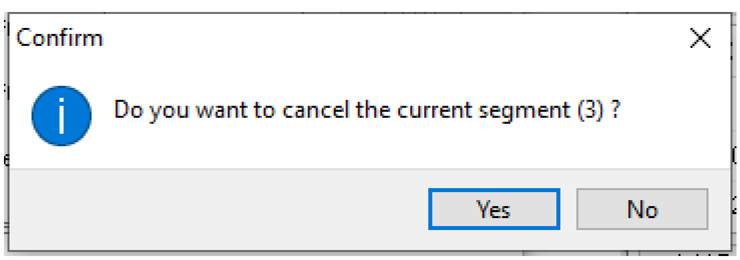


Figure 3.11 Warming message after clicking “Cancel Segment” before completing definition of segment

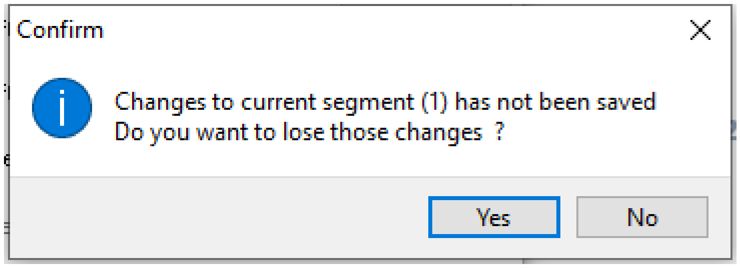


Figure 3.12 Warning message after closing window before completing definition of segment

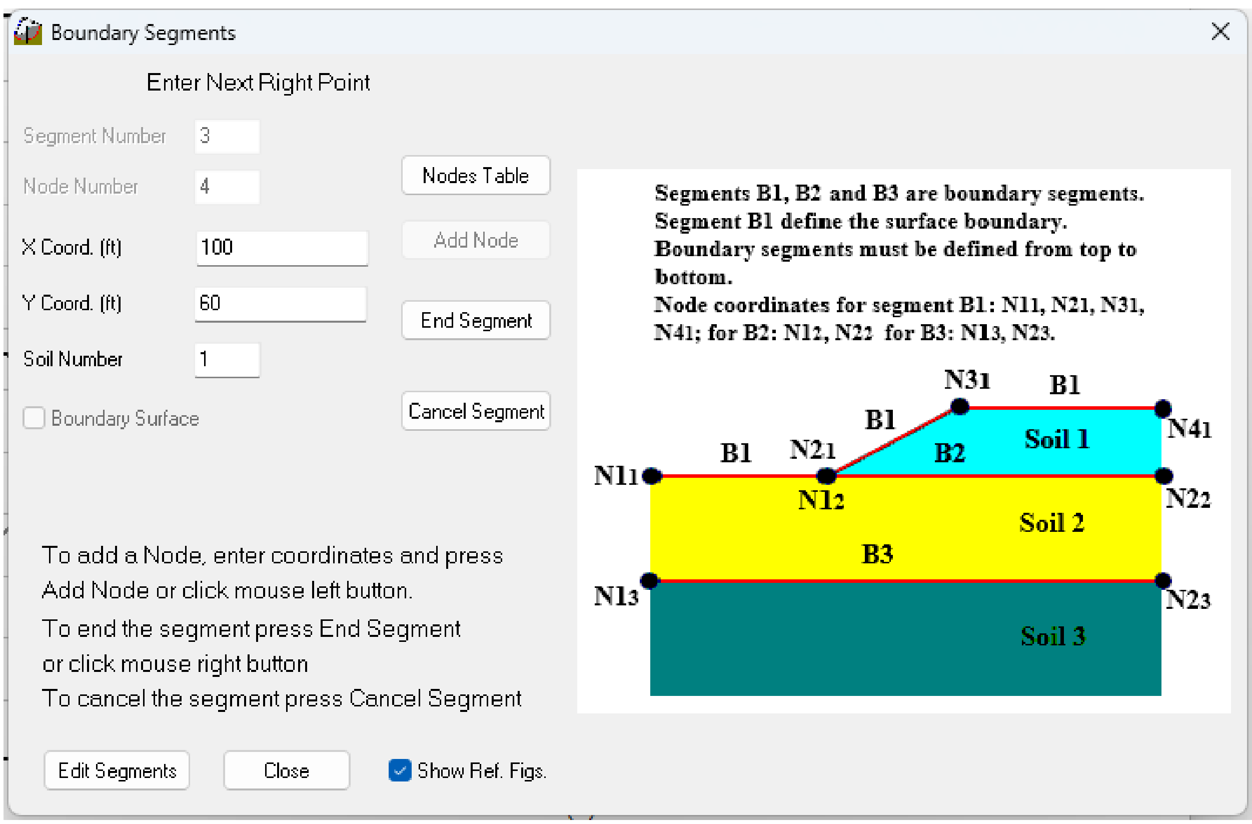


Figure 3.13 Window Adding Boundary Segments after checking on Show Rel. Figs.

Editing Segments

The editing segments option will show up automatically if boundary segments were already defined on the model or after clicking on the "Edit Segments" button at the left bottom corner of the Boundary Segments window. Also, the editing segments option will show up by double-clicking over a segment while in Input Mode.

Please note that the current segment is displayed in red color while the other segments are displayed in black color (Figure 3.14). For the current segment, the current node is displayed as a circle of maroon color while others as circles of gray color.

Enter the segment number desired to view/edit in the Segment Number field or select it using the up/down buttons at the right of the Segment Number field.

Enter the node number desired to view/edit in the Node Number field or select it using the up/down buttons at the right of the Node Number field.

Click on List Nodes to show and if desired edit all the nodes corresponding to the current segment.

Click on Update Node if wanted to change the coordinates of the current node. Please note that the Update Node button is enabled if a change has been detected to the current node coordinates.

Click on Add Node to add at the end of the segment using the given coordinates.

Click on Insert Node to insert a node after the current node using the given coordinates.

Click on Delete Node to delete the current node.

Click on Delete Segment to delete the current segment.

Click on Close to close the window Boundary Segments.

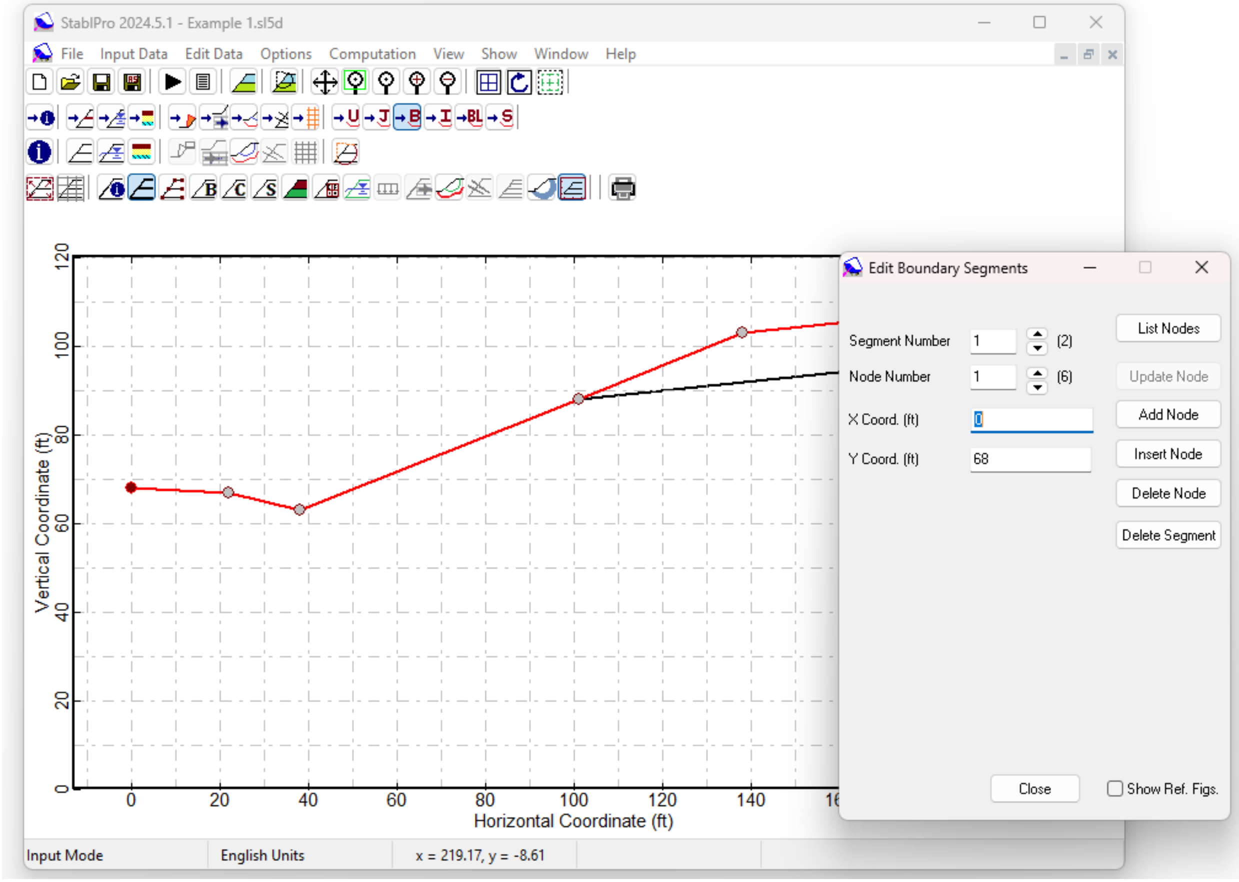


Figure 3.14 Window screen for sample Data – Boundary Segments (editing option)

3.3.6 Data –Piezometric Surfaces

The window Piezometric Surfaces will appear on the screen if Item – **Piezometric Surfaces** of the Data Menu is selected (Figure 3.15). This window allows the user to enter interactively the coordinates of the piezometric surfaces and/or edit piezometric surfaces already defined.

Adding Surfaces

The adding surfaces option will show up automatically if no surface was defined before or after clicking on the "Add Surfaces" button at the left bottom corner of the Piezometric Surfaces window.

There are three ways to enter a piezometric surface: Inputting the node coordinates one by one using the mouse, entering the node coordinates one by one using the entry fields, and entering the nodes using a table. Also, the node coordinates can be entered as a combination of the three ways listed:

1. Using the mouse

To add a node, click the mouse left button. To end a surface, click the mouse's right button.

2. Using the entry fields

To add a node, enter the coordinates of the node in the X Coord and Y Coord entry fields and press on the Add Node button. To end a surface, press the End Surface button.

3. Using the table

Press on the Nodes Table button and the Nodes Table will show up. Please enter the X, and Y coordinates. Close the table using the X box on the top right corner to close the table and return to the Adding Piezometric Surfaces window. To end the surface, press the End Surface button or click the right mouse button.

<u>Notes</u>

- As the nodes are entered, the current water surface will be displayed in a light blue color and the already-defined surfaces are displayed in a blue color as displayed in Figure 3.15.
- After adding a node, the new node number will be displayed in the Node Number field.
- After completing a surface, the new surface number will be displayed in the Surface Number field.
- As the mouse moves, the coordinates are displayed in the status bar.

To cancel the current entries on the surface, please click on the Cancel Surface button, then a prompt will appear to confirm the cancelation process. Click on Yes to confirm the cancelation; otherwise, click on No to continue defining the current surface.

Click on Close to close the window Adding Piezometric Surfaces. If the current surface has not been completed, then a prompt will appear indicating that the current changes have not been completed. Click on Yes to confirm losing the latest entries; otherwise, click on No to continue defining the current surface.

By checking on the option Show Rel. Figs. The window will display a figure related to the definition of piezometric surfaces (Figure 3.16).

Unit Weight of Water

This is the unit weight for the water. The English unit for this variable is “pcf”, while “kN/m^3” is for the SI unit.

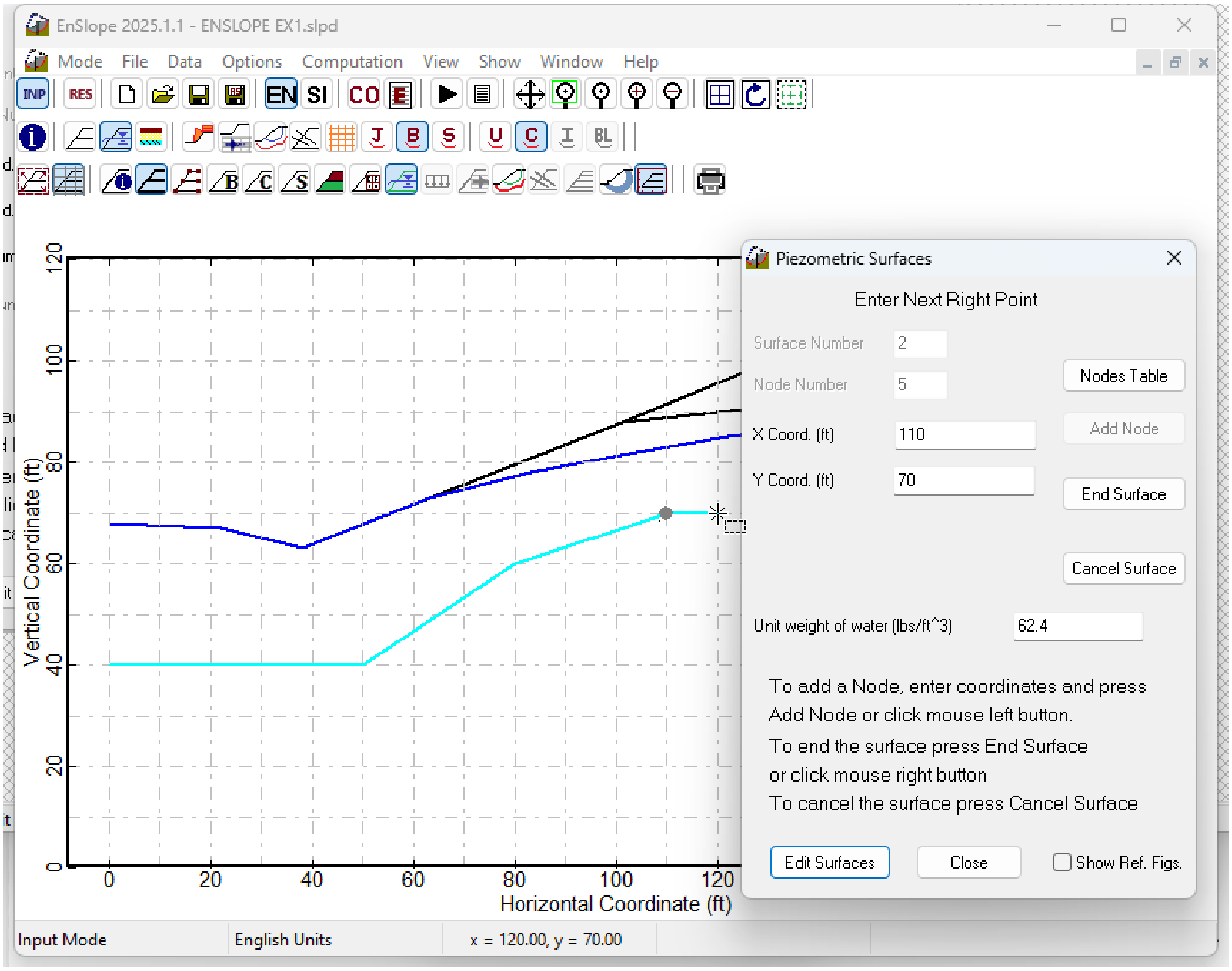


Figure 3.15 Window screen for sample Input Data – Piezometric Surfaces

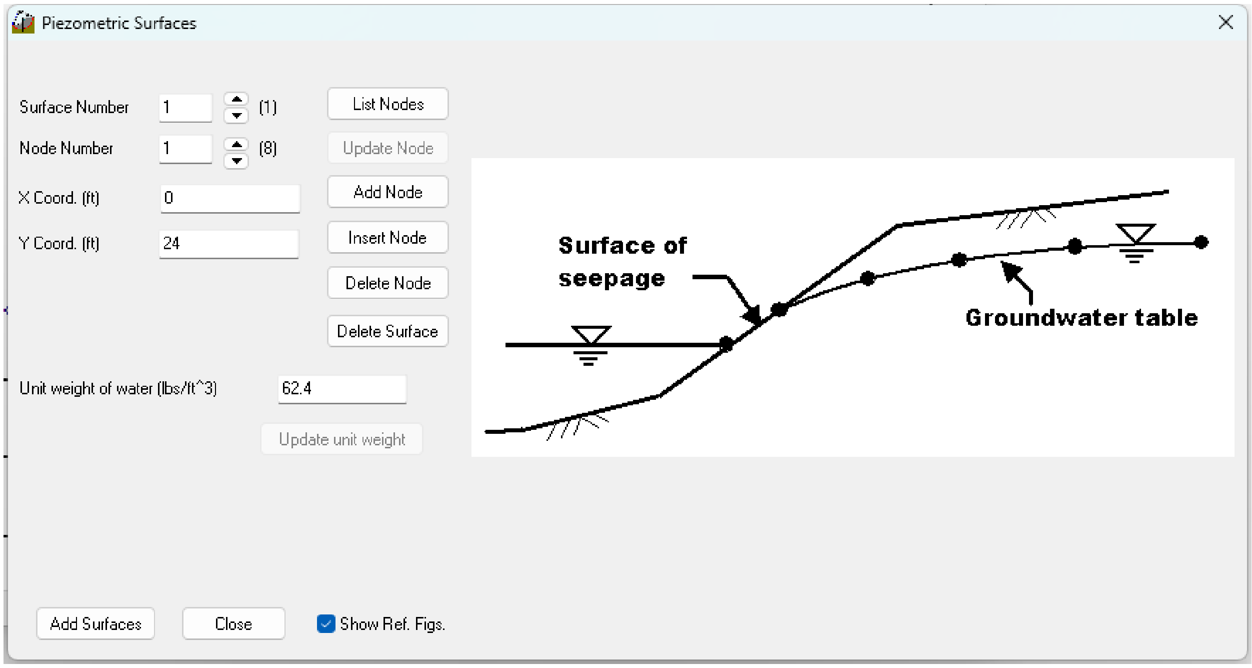


Figure 3.16 Window Piezometric Surfaces after checking on Show Rel. Figs.

Editing Surfaces

The editing segments option will show up automatically if piezometric surfaces were already defined on the model or after clicking on the "Edit Surfaces" button at the left bottom corner of the Piezometric Surfaces window. Also, the editing surfaces option will show up by double-clicking over a piezometric surface while in Input Mode.

Please note that the current surface is displayed in purple color (Figure 3.17), while the other segments are displayed in blue color. For the current surface, the current node is displayed as a circle of maroon color while others as circles of gray color.

Enter the surface number desired to view/edit in the Surface Number field or select it using the up/down buttons at the right of the Surface Number field.

Enter the node number desired to view/edit in the Node Number field or select it using the up/down buttons at the right of the Node Number field.

Click on List Nodes to show and if desired edit all the nodes corresponding to the current surface.

Click on Update Node if wanted to change the coordinates of the current node. Please note that the Update Node button is enabled if a change has been detected to the current node coordinates.

Click on Add Node to add at the end of the surface using the given coordinates.

Click on Insert Node to insert a node after the current node using the given coordinates.

Click on Delete Node to delete the current node.

Click on Delete Surface to delete the current surface.

Click on Close to close the window Piezometric Surfaces.

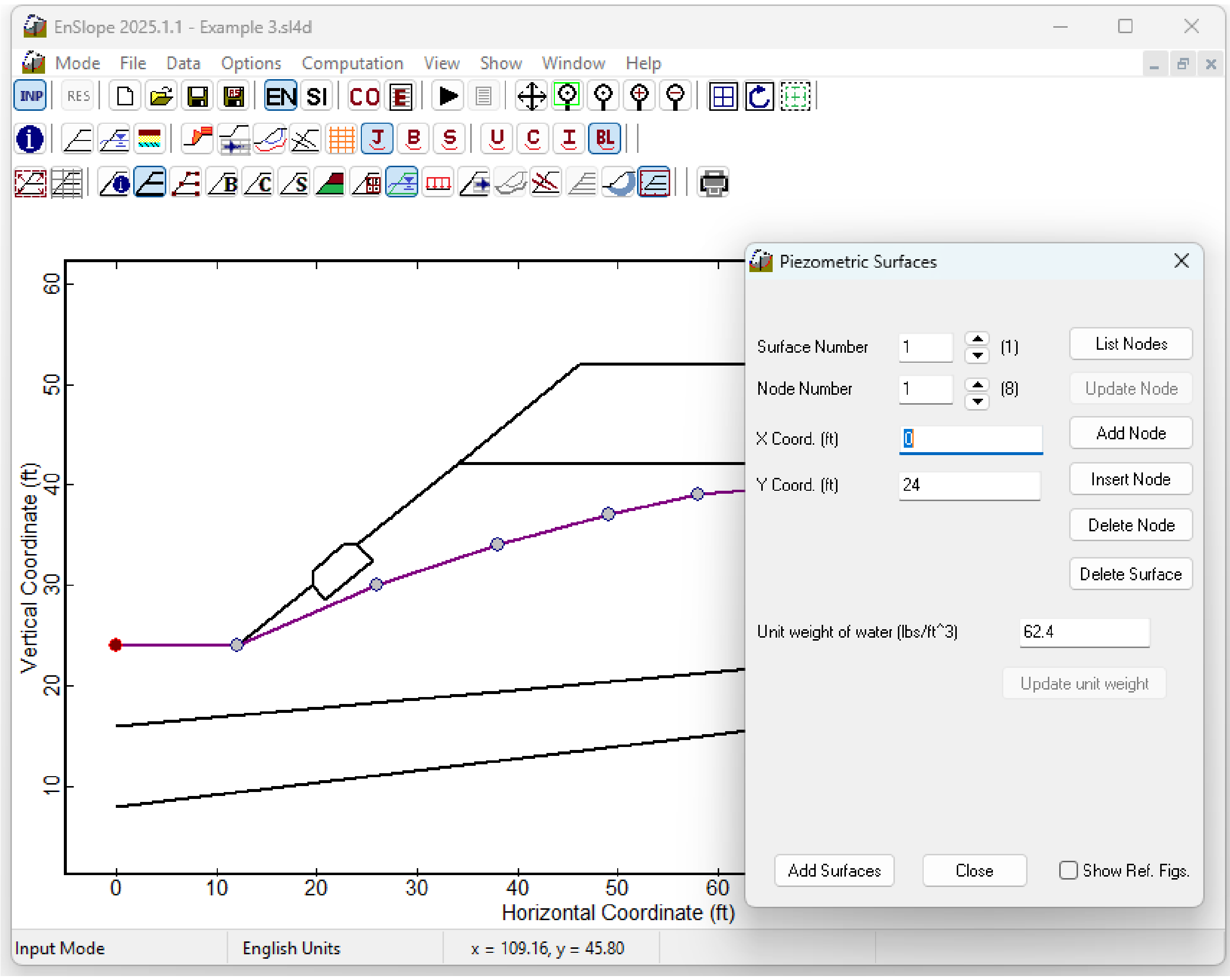


Figure 3.17 Window screen for sample Data – Piezometric Surfaces (editing mode)

3.3.7 Data –Soil Properties

The Soil Properties item from the Data menu may be clicked and the input screen for soil properties will be shown on the screen (Figure 3.18). Also, the Soil Properties window will show up by double-clicking over a soil layer number while in Input Mode. A total of 20 different types of soil can be specified. The soil parameters for each type of soil are moist unit weight, saturated unit weight, strength intercept for isotropic soil, strength angle for isotropic soil, pore-pressure parameter, pore-pressure constant, and the index number for the piezometric surface. The units should be consistent throughout the input of data.

If the strength properties are judged to be significantly anisotropic, the soil types exhibiting anisotropic strength properties should be specified on the screen. Once the anisotropic option for each soil type is clicked, another table will be shown on the screen for entering the soil's anisotropic properties as shown in Figure 3.19. A general description of the input needed under each item of the Data –Soil Properties submenu option is listed below.

Soil Number

This is the number assigned to each soil type, which corresponds to the entry in the earlier section for boundary segments. The maximum number of soil properties should be equal to the maximum soil type number that has been selected in profile entries.

Moist Unit Weight

This is the moisture unit weight (in-situ unit weight) for the soil. If a soil layer is above the water surface, the program will use the moist unit weight for computation. The English unit for this variable is "pcf", while "kN/m^3" is for the SI unit.

Saturated Unit Weight

This is the fully saturated unit weight for the soil. In the case of a soil layer is below the water surface, the program will use the saturated unit weight for computation. The English unit for this variable is "pcf", while "kN/m^3" is for the SI unit.

Isotropic Strength Intercept

This is the cohesive strength c for an isotropic cohesive soil. Either an effective stress analysis (ϕ', c') or total stress analysis (c, ϕ=0) may be performed by selecting the appropriate value for the Mohr-Coulomb strength parameters. The English unit for this variable is "psf", while "kN/m^2" is for the SI unit.

Isotropic Strength Angle

This is the internal friction angle for an isotropic cohesionless soil. Either an effective stress analysis (ϕ', c') or total stress analysis (c, ϕ=0) may be performed by selecting the appropriate value for the Mohr-Coulomb strength parameters. The unit for this variable is "degree".

Pore Pressure Parameter

Excess pore water pressure due to shear can be assumed to be related to the overburden by this single pore-pressure parameter (r_u). The overburden does not include surcharge boundary loads.

Pore Pressure Constant

The pore pressure constant (u_c) of a soil type defines a constant pore pressure for any point within the soil described. The English unit for this variable is "psf", while "kN/m^2" is for the SI unit.

Piezometric Surface Number

This is the piezometric line associated with the current soil layer. Please note that the piezometric surface associated with the current soil is displayed in blue. The piezometric line can be assigned by entering the number in the field by selecting it using the up-down arrows or by selecting it graphically. To use the latest option, click on the Select Piezometric Surfaces item from the View menu, then select the piezometric lines to be associated with the current soil line, the lines selected will be displayed in maroon color. Finally, click on the option Use Selected Piezometric Surface.

The boundary lines may be associated with the soil layer while adding the boundary segments, or they can be associated by adding the soil type. Please note that the boundary lines associated with the current soil are displayed in purple. To associate boundary lines to the current soil type, click on the Select Boundary Lines item from the View menu, then select the lines to be associated with the current soil line, the lines selected will be displayed in red color. Finally, click on the option Associate Selected Boundary Lines to Current Soil Number. If the Append Action is checked the selected lines will be added to the already defined lines; however, if the Replace Action is checked the selected lines will replace the already defined lines.

To save the changes to the current soil layer Click on Apply to keep the Soil Properties Window open or Save and Close to save the changes and close the window. After saving the changes, Click on Add New Soil to define a new soil type. If a user wants to copy the current parameters to the new soil defined, check on Copy Cur. Values first.

If a user wants to copy the parameters from an already defined soil, select the soil number in the Soil Source dropdown menu and then click on Copy.

To delete the current soil layer, Click on Delete Current Soil. The program will show up a window to confirm or cancel the delete action

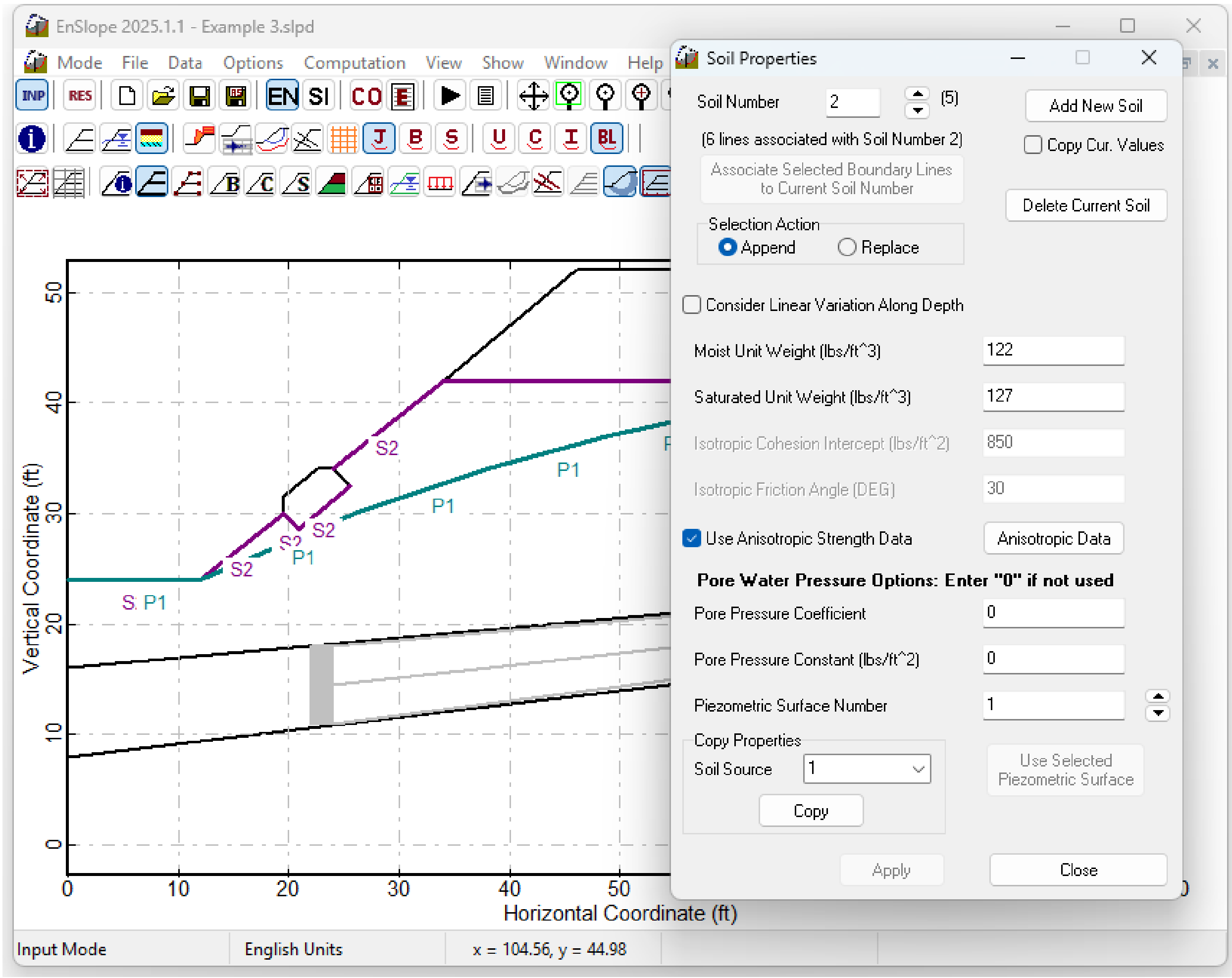


Figure 3.18 Window screen for sample Data – Soil Properties

Anisotropic Soil

The soil types exhibiting anisotropic strength properties should be specified. First, click on Use Anisotropic Strength Data, so the Anisotropic Data button will be enabled. Also note, that the isotropic entries for cohesion and friction angle are disabled. Once the anisotropic option for each soil type is clicked, another table will be shown on the screen for entering the soil's anisotropic properties as shown in Figure 3.19. Each direction range of an anisotropic soil type is established by specifying the maximum (counterclockwise) inclination angle (in degrees) of each discrete range. The data set consists of the inclination angle (α), the Mohr-Coulomb strength angle (ϕ), and the strength intercept (c) for each discrete range. Data for each discrete range is required to be prepared progressing in counterclockwise order, starting with a first range from –90 degrees to α_1 (specifying α_1 as the next counterclockwise direction angle), then to the last range of +90 degrees. The process is repeated for each soil type with anisotropic strength behavior.

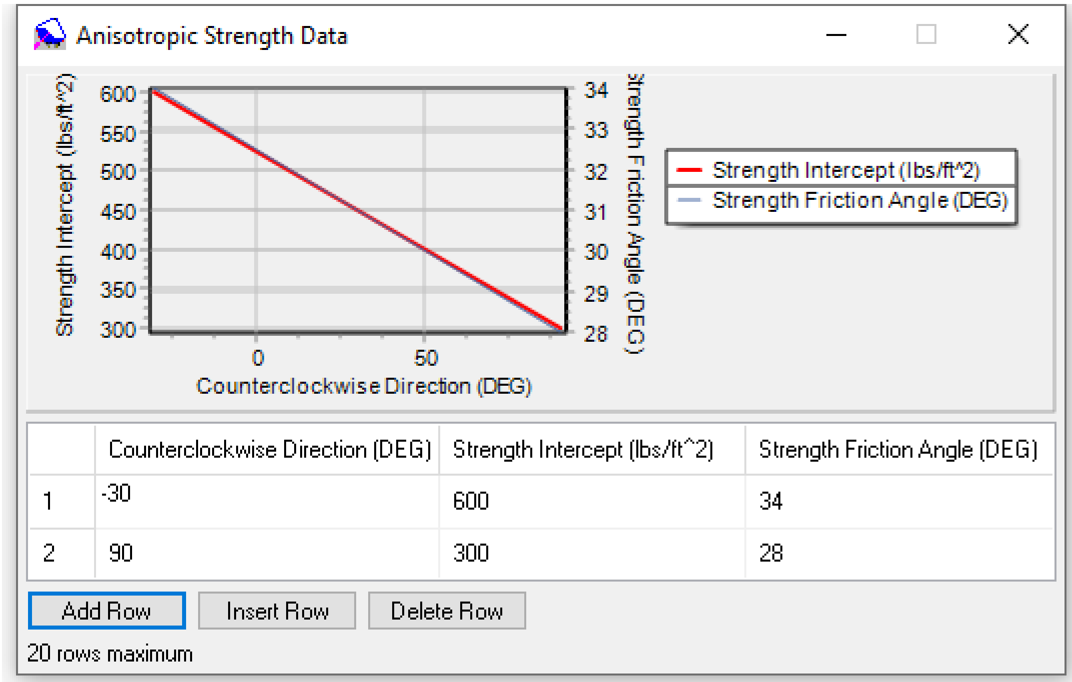


Figure 3.19 Window screen for sample Data – Anisotropic Strength Data

Linear Variation of Strength Data

The program allows for a linear variation of strength data (cohesion and friction angle) along depth. To consider this option click on Consider Linear Variation Along Depth. The window Soil Properties will accommodate new entries to define the linear variation of strength data along depth as shown in Figure 3.20. Enter the values for the depth of reference (Y coordinate) at the top and the depth of reference at the bottom. Also, enter the values for Cohesion and Friction Angle at the bottom. If Anisotropic Strength Data is being used, anisotropic data for both, the top and bottom must be entered.

Please note that the program will interpolate linearly between the values of top and bottom using the reference coordinates for top and bottom. If a point is deeper than the reference bottom, the program will use the values defined at the bottom. If a point is higher than the reference top, the program will use the values defined at the top.

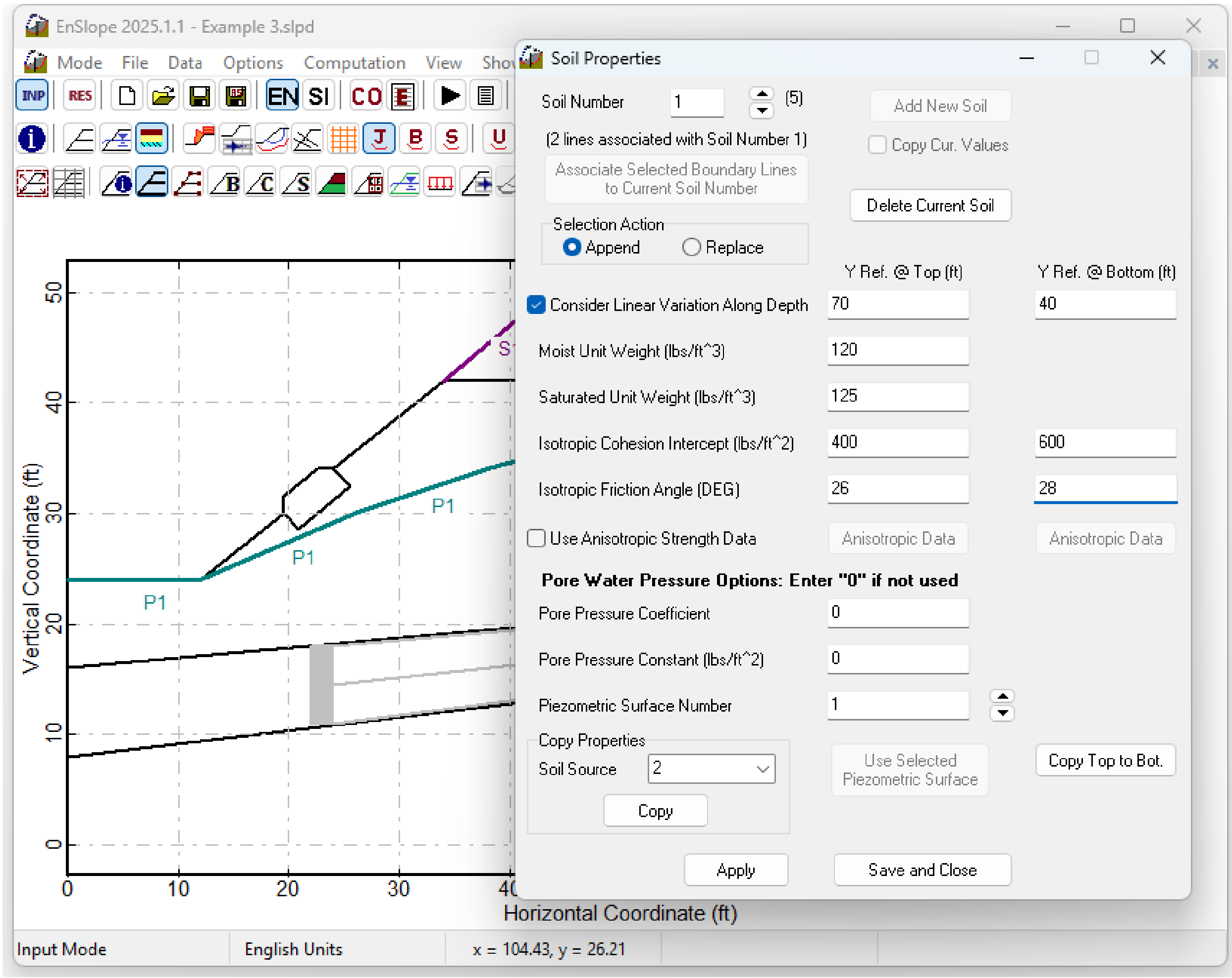


Figure 3.20 Window screen for sample Data – Linear Variation of Strength Data

3.3.8 Data –Surcharge Loading

External boundary loads applied to the slope are defined by the menu command, Surcharge, and Earthquake Loading. Input of up to 10 loads is allowed, as a surcharge intensity in any direction. A boundary load of varying linear intensity can be defined.

To open the input screen for boundary surcharge load, the user selects Item –**Surcharge Loading** from the Data menu. The Surcharge Load window will be displayed as shown in Figure 3.21. Also, the Surcharge Loading window will show up by double-clicking over a surcharge load while in Input Mode.

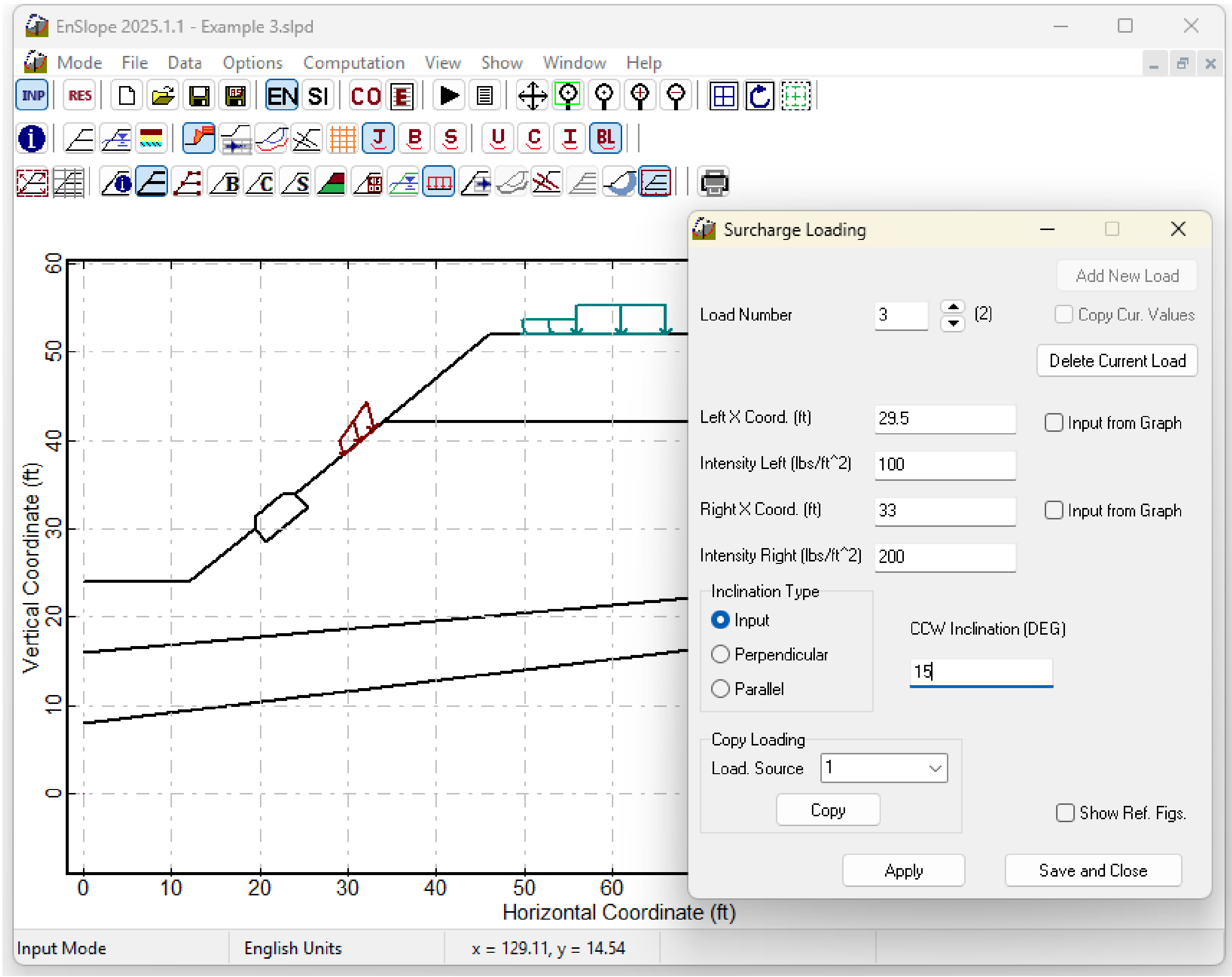


Figure 3.21 Window screen for sample Input Data – Adding Surcharge Loading

The boundary surcharge loads may be specified on the input screen, as shown in Figure 3.21.

Load Number

This is the number assigned to each surcharge load defined. A maximum number of 10 loads is allowed.

Left X Coordinate

This is the X coordinate of the first endpoint of the application of surcharge load (ft) or (m). If desired, the user can get the Left X coordinate from the graph by clicking the mouse if the Input from Graph option is checked.

Intensity Left

This is the surface load intensity at the first endpoint of application of the surcharge load (lbs/ft^2) or (kN/m^2).

Right X Coordinate

This is the X coordinate of the second endpoint of the application of surcharge load (ft) or (m). If desired, the user can get the Right X coordinate from the graph by clicking the mouse if the Input from Graph option is checked.

Intensity Right

This is the surface load intensity at the second endpoint of the application of the surcharge load (lbs/ft^2) or (kN/m^2).

Inclination Type

The load inclination can be defined by selecting the Inclination type:

- Input, by entering the counterclockwise angle.
- Perpendicular, the load is perpendicular to the line segment.
- Parallel, the load is parallel to the line segment.

CCW Inclination

This is the load inclination angle measured counterclockwise (deg).

Please note that the surcharge load already defined is displayed in light blue. The current surcharge load being defined is displayed in maroon color. The program uses a default scale, the user can change the scaling under the Show Options item in the Show menu.

To save the changes to the current surcharge loading Click on Apply to keep the Adding Surcharge Loading Window open or Save and Close to save the changes and close the window. After saving the changes, Click on Add New Load to define a new surcharge loading. If a user wants to copy the current parameters to the new surcharge defined, check on Copy Cur. Values first.

If a user wants to copy the values from an already defined surcharge, select the surcharge number in the Load Source dropdown menu and then click on Copy.

To delete the current surcharge load, Click on Delete Current Load. The program will show a window to confirm or cancel the delete action

By checking on the option Show Rel. Figs. The window will display a figure related to the definition of surface loading (Figure 3.22).

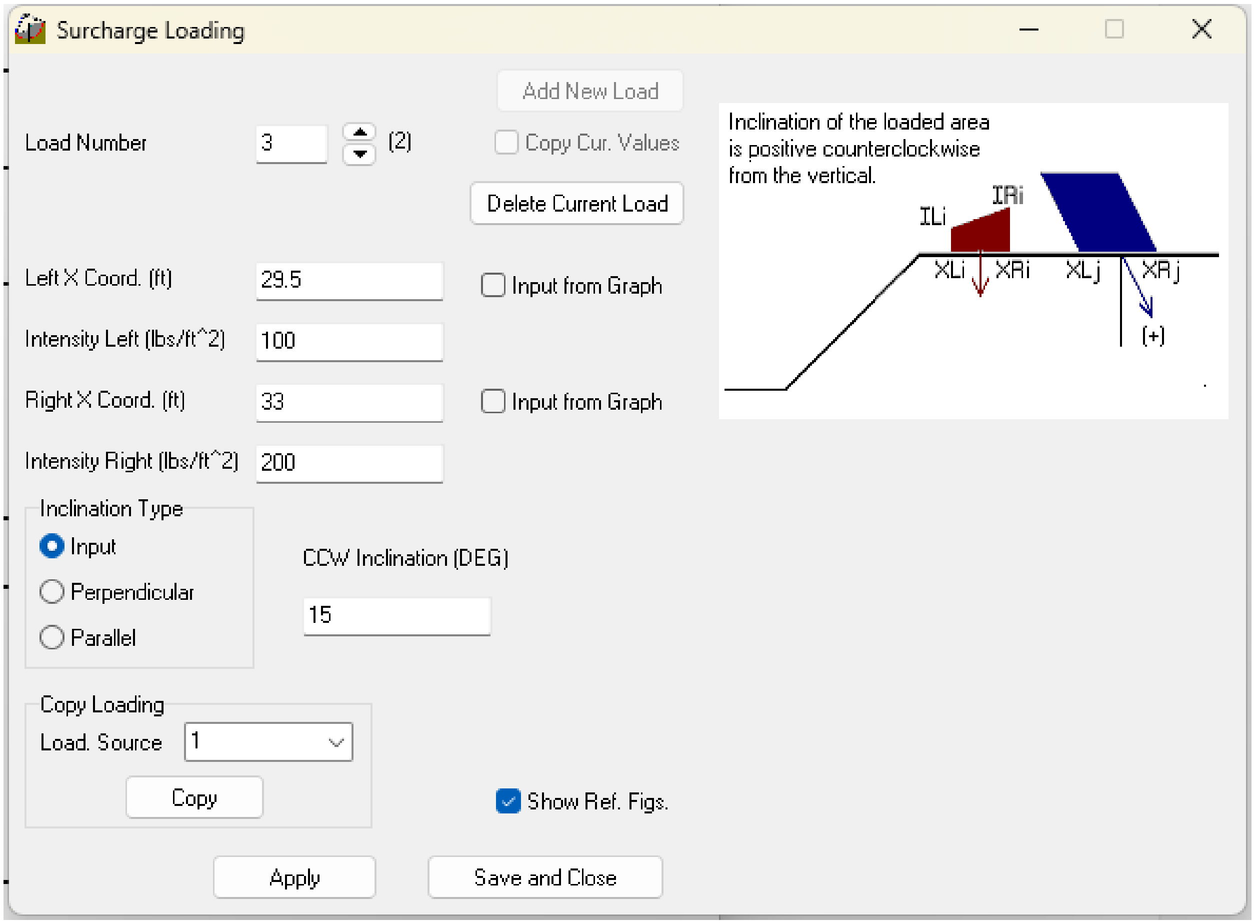


Figure 3.22 Window Adding Surcharge Loading after checking on Show Rel. Figs.

3.3.9 Data –Earthquake Loading

For a pseudo-static earthquake analysis, the menu earthquake loading is used to assign vertical and horizontal coefficients to simulate the design earthquake.

To open the input screen for earthquake load, the user selects Item – **Earthquake Loading** from the Data menu. The Earthquake Load window will be displayed as shown in Figure 3.23. Also, the Earthquake Loading window will show up by double clicking over earthquake load values while in Input Mode.

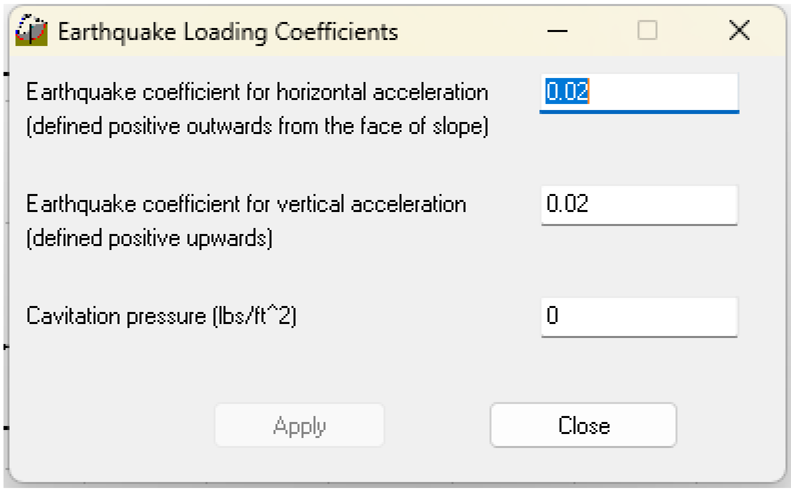


Figure 3.23 Window screen for sample Input Data –Earthquake Loading

If earthquake loading is applicable, values for all three fields designated for the earthquake condition must be entered (Figure 3.23). The data needed for earthquake loads are the coefficient for horizontal acceleration, the coefficient for vertical acceleration, and cavitation pressure (optional). Click on the Save and Close button to save the values and close the window. Click on the X box (upper right corner) to close the window without saving the changes.

3.3.10 Data –Trial Surface Limits

EnSlope can automatically search for the failure surface based on the boundaries that are specified. If the user wishes to confine critical surfaces within certain zones, the option for Trial Surface Limit may be used. The generation of critical planes is beyond the defined limiting boundary, such as competent rock underlying the slope. Alternatively, one could simply introduce the rock as a soil type with a high strength, which would effectively lead to higher factors of safety (FOS) for a surface passing through the rock. However, the surface limits option is more efficient because computer time is not wasted in computing a high FOS.

Additionally, an upper limiting boundary can be implemented which is useful for stability analysis of retaining structures such as sheet-pile walls, anchored bulkheads, reinforced earth walls, and related structures.

The window Trial Surface Limits will appear on the screen if Item –**Trial Surface Limits** of the Data Menu is selected (Figure 3.24). This window allows the user to enter interactively the coordinates of the trial surface limits and/or edit surface limits already defined.

Adding Surfaces

The adding surfaces option will show up automatically if no surfaces were defined before or after clicking on the “Add Surfaces” button at the left bottom corner of the Trial Surface Limits window.

There are three ways to enter a trial surface limit: Inputting the node coordinates one by one using the mouse, entering the node coordinates one by one using the entry fields, and entering the nodes using a table. Also, the node coordinates can be entered as a combination of the three ways listed:

1. Using the mouse

To add a node, click the mouse left button. To end a surface, click the mouse's right button.

2. Using the entry fields

To add a node, enter the coordinates of the node in the X Coord and Y Coord entry fields and press the Add Node button. To end a surface, press the End Surface button.

3. Using the table

Press on the Nodes Table button and the Nodes Table will show up. Please enter the X, and Y coordinates. Close the table using the X box on the top right corner to close the table and return to the Adding Trial Surface Limits window. To end the surface, press the End Surface button or click the right mouse button.

Notes

- As the nodes are entered, the current trial surface limit will be displayed in purple color and the already-defined surfaces will be displayed in orange color as displayed in Figure 3.24.
- After adding a node, the new node number will be displayed in the Node Number field.
- After completing a surface, the new surface number will be displayed in the Surface Number field.
- As the mouse moves, the coordinates are displayed in the status bar.

To cancel the current entries on the surface, please click on the Cancel Surface button, then a prompt will appear to confirm the cancelation process. Click on Yes to confirm the cancelation; otherwise, click on No to continue defining the current surface.

Click on Close to close the window Adding Trial Surface Limits. If the current surface has not been completed, then a prompt will appear indicating that the current changes have not been completed. Click on Yes to confirm losing the latest entries; otherwise, click on No to continue defining the current surface.

By checking on the option Show Rel. Figs. The window will display a figure related to the definition of trial surface limits (Figure 3.25).

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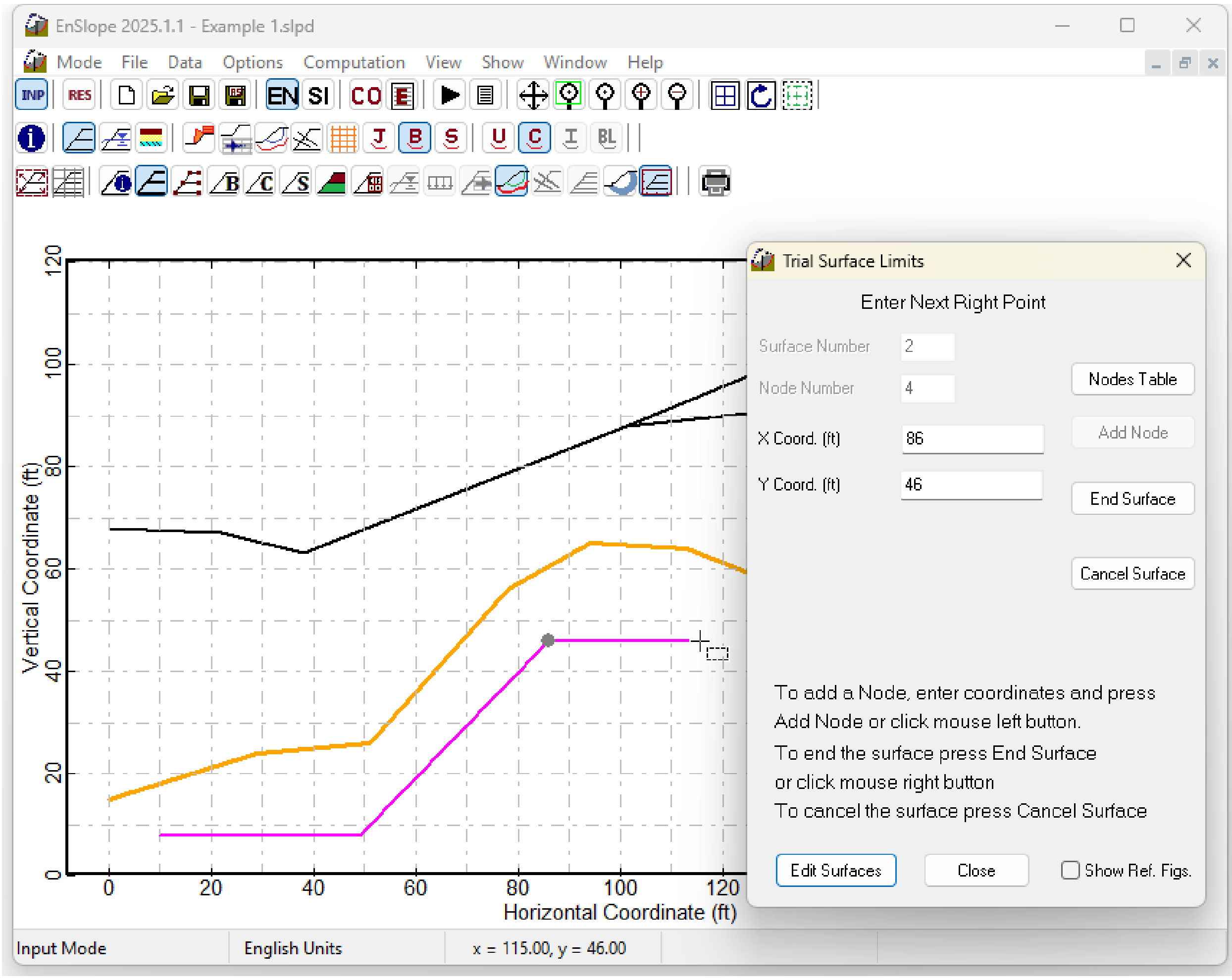

Figure 3.24 Window screen for sample Input Data – Add Trial Surface Limits

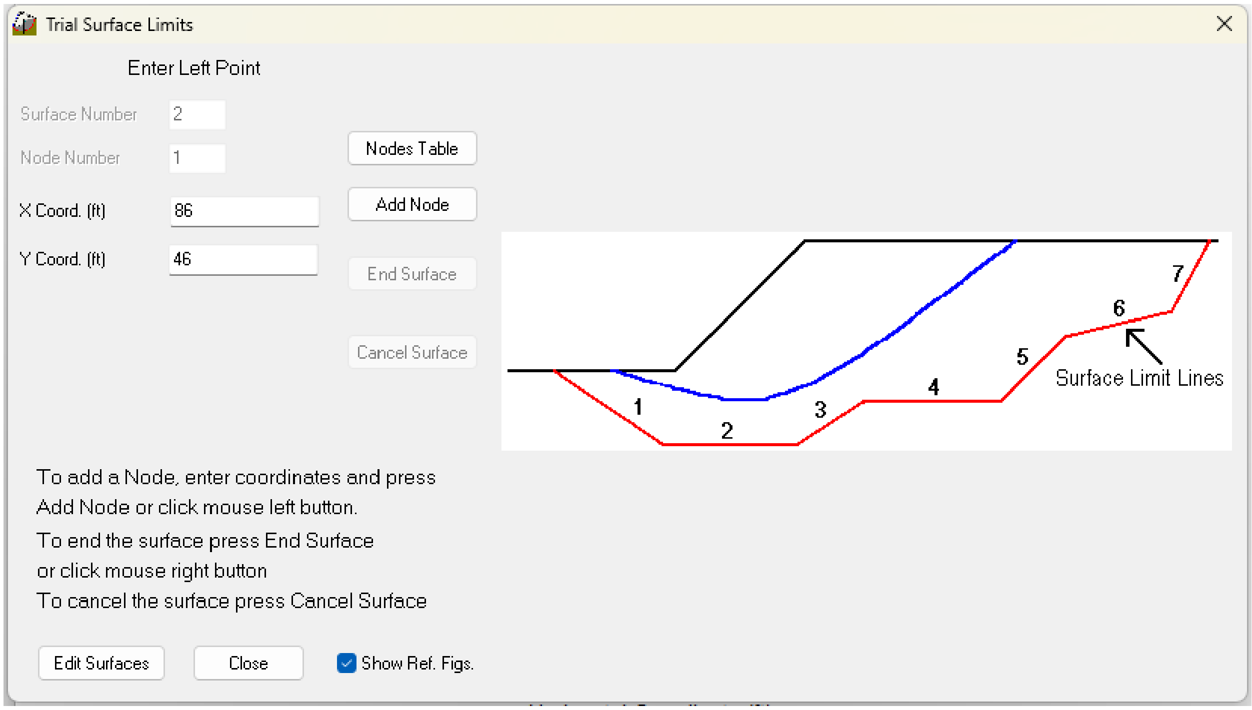

Figure 3.25 Window Trial Surface Limits after checking on Show Rel. Figs.

Editing Surfaces

The editing segments option will show up automatically if trial surfaces were already defined on the model or after clicking on the "Edit Surfaces" button at the left bottom corner of the Trial Surface Limits window. Also, the editing surfaces option will show up by double-clicking over a trial surface while in Input Mode

Please note that the current surface is displayed in teal color while the other segments are displayed in yellow color. For the current surface, the current node is displayed as a circle of maroon color while others as circles of gray color.

Click on List Nodes to show and if desired edit all the nodes corresponding to the current surface.

Click on Update Node if wanted to change the coordinates of the current node. Please note that the Update Node button is enabled if a change has been detected to the current node coordinates.

Click on Add Node to add at the end of the surface using the given coordinates.

Click on Insert Node to insert a node after the current node using the given coordinates.

Click on Delete Node to delete the current node.

Click on Delete Surface to delete the current surface.

Click on Close to close the window Edit Trial Surface Limits.

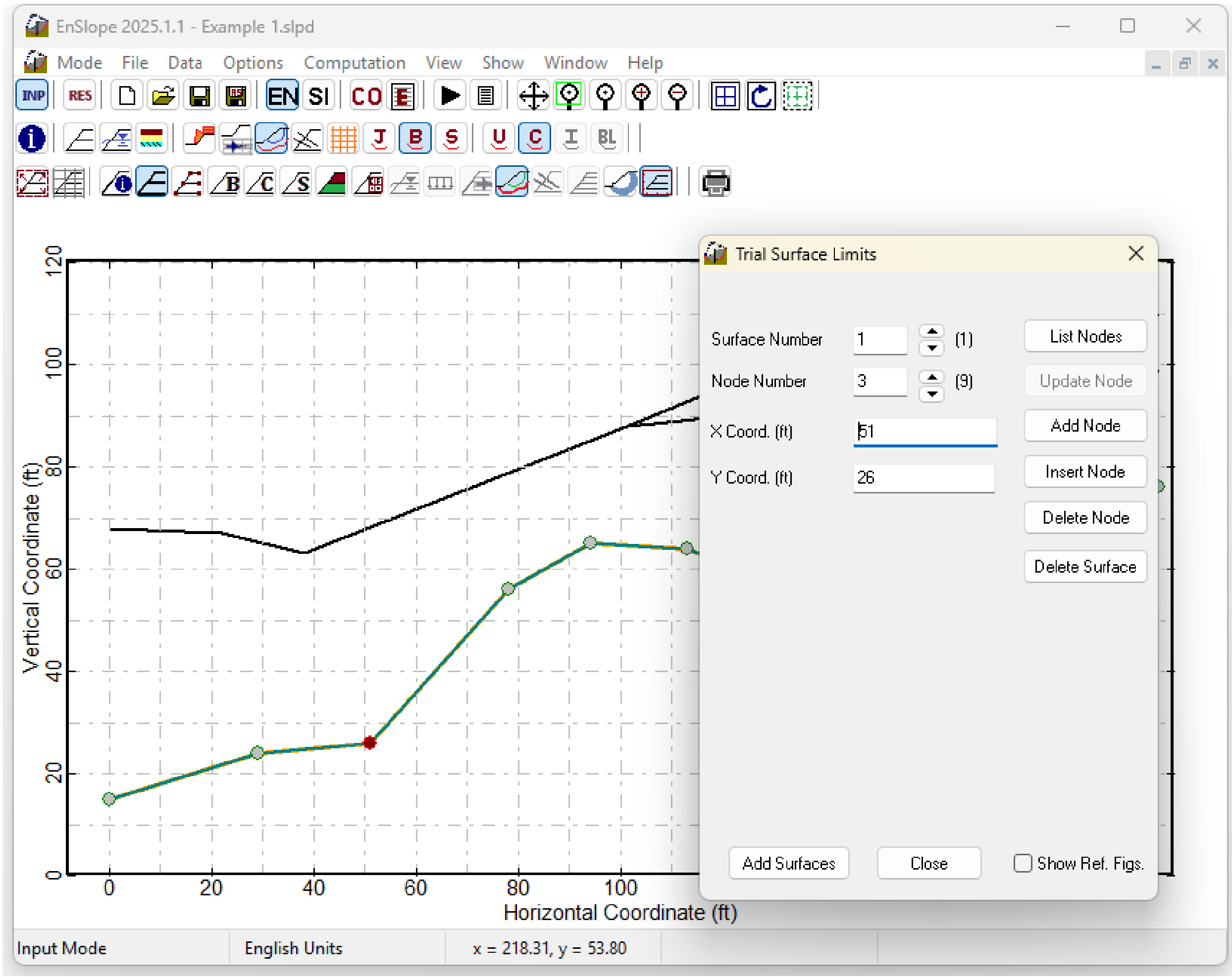

Figure 3.26 Window screen for sample Data – Trial Surface Limits (editing mode)

3.3.11 Data –Tiebacks

Program EnSlope allows the user to specify tieback loads on the slope. Procedures to compute the factor of safety will include the effects of tiebacks. Tieback or concentrated loads applied to the slope are defined by the option tiebacks. This option allows input of up to 10 horizontal or inclined concentrated loads to be applied to the profile surface. The tiebacks option is fully described in the technical manual.

To open the input screen for tiebacks, the user selects Item –**Tiebacks** from the Data menu. The Tiebacks window will be displayed as shown in Figure 3.27. Also, the Tiebacks window will show up by double-clicking over a tieback while in Input Mode

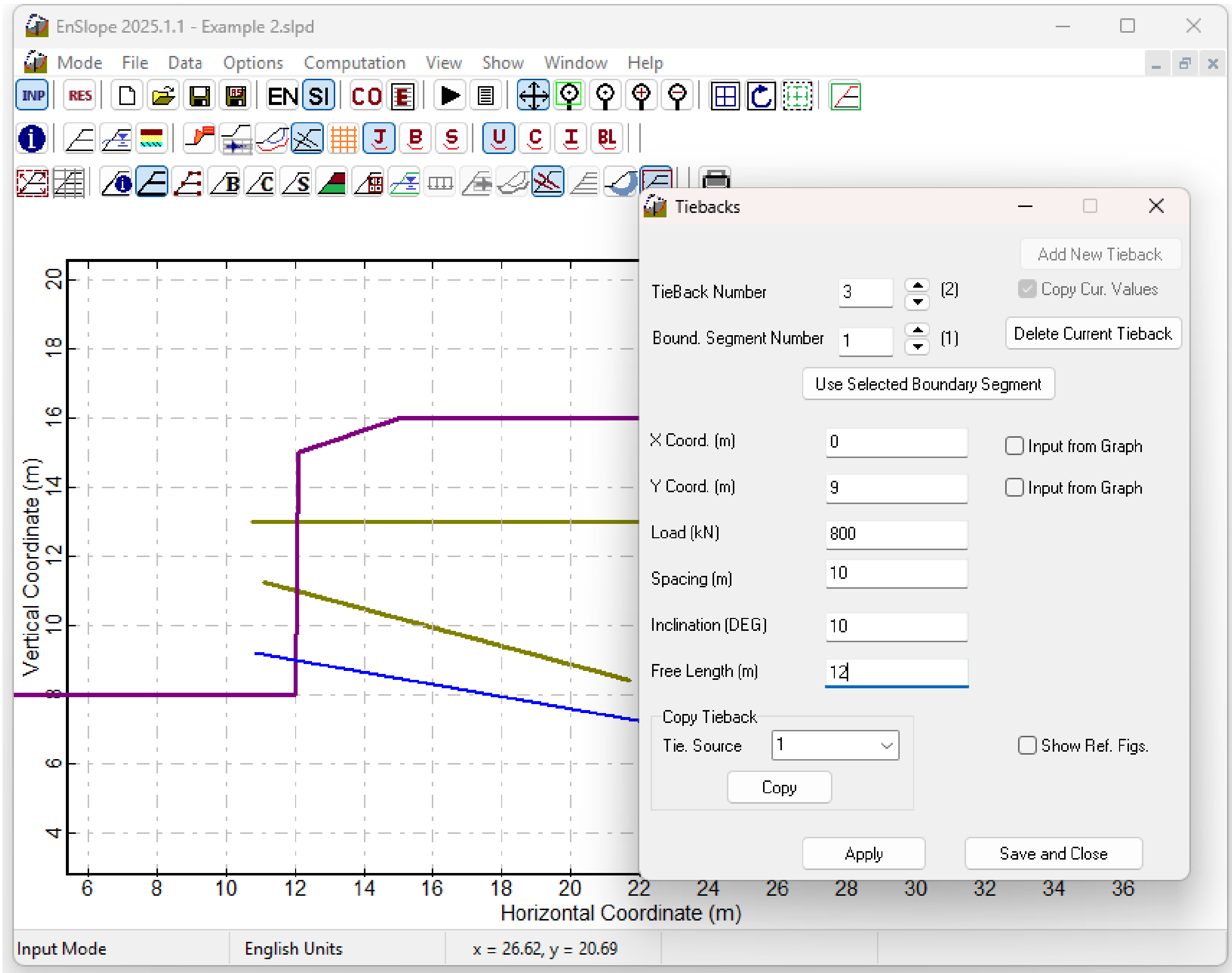

Figure 3.27 Window screen for sample Data –Tiebacks

Up to ten tiebacks can be specified on the cross-section of a slope.

Boundary Segment Number

This is the boundary segment number where the tieback load is applied. Please note that the boundary surface associated with the current tieback is displayed in purple. The boundary segment can be assigned by entering the number in the field, by selecting it using the up-down arrows, or by selecting it graphically. To use the latest option, click on the Select Boundary Segments item from the View menu, then select the boundary segment to be associated with the current tiebacks, the lines selected will be displayed in red color. Finally, click on the option Use Selected Boundary Segment.

X Coordinate

This is the X coordinate of the point of application of the tieback load. If the Y coordinate is equal to zero, the program will estimate the Y coordinate of the point of application of the tieback load by intersecting a vertical line to the boundary segment. If both the X and Y coordinates are equal to zero, the program will estimate the point of application of the load by intersecting a perpendicular line to the boundary segment. If desired the user can get the X coordinate from the graph by clicking the mouse if the Input by Graph is checked.

Y Coordinate

This is the Y coordinate of the point of application of the tieback load. If the X coordinate is equal to zero, the program will estimate the X coordinate of the point of application of the tieback load by intersecting a horizontal line to the boundary segment. If both the X and Y coordinates are equal to zero, the program will estimate the point of application of the load by intersecting a perpendicular line to the boundary segment. If desired the user can get the Y coordinate from the graph by clicking the mouse if the Input by Graph is checked.

Load

This is the load per tieback (lbs) or (kN).

Spacing

This is the horizontal spacing between tiebacks (ft) or (m). The distance between two cross sections with tiebacks is required because the force on each plane section will be averaged, based on the tieback distance.

Inclination

This is the inclination of the tieback measured clockwise from the horizontal plane (deg).

Free Length

This is the free length of the tieback (ft) or (m) [equal to zero if other than tieback load].

Please note that the tieback already defined is displayed in light green. The current tieback being defined is displayed in blue color.

To save the changes to the current tieback Click on Apply to keep the Tieback Window open or Save and Close to save the changes and close the window. After saving the changes, Click on Add New Tieback to define a new tieback. If a user wants to copy the current values to the new tieback defined, check on Copy Cur. Values first.

If a user wants to copy the values from an already defined tieback, select the tieback number in the Tie Source dropdown menu and then click on Copy.

To delete the current tieback, Click on Delete Current Tieback. The program will show up a window to confirm or cancel the delete action

By checking on the option Show Rel. Figs. The window will display a figure related to the definition of tiebacks (Figure 3.28).

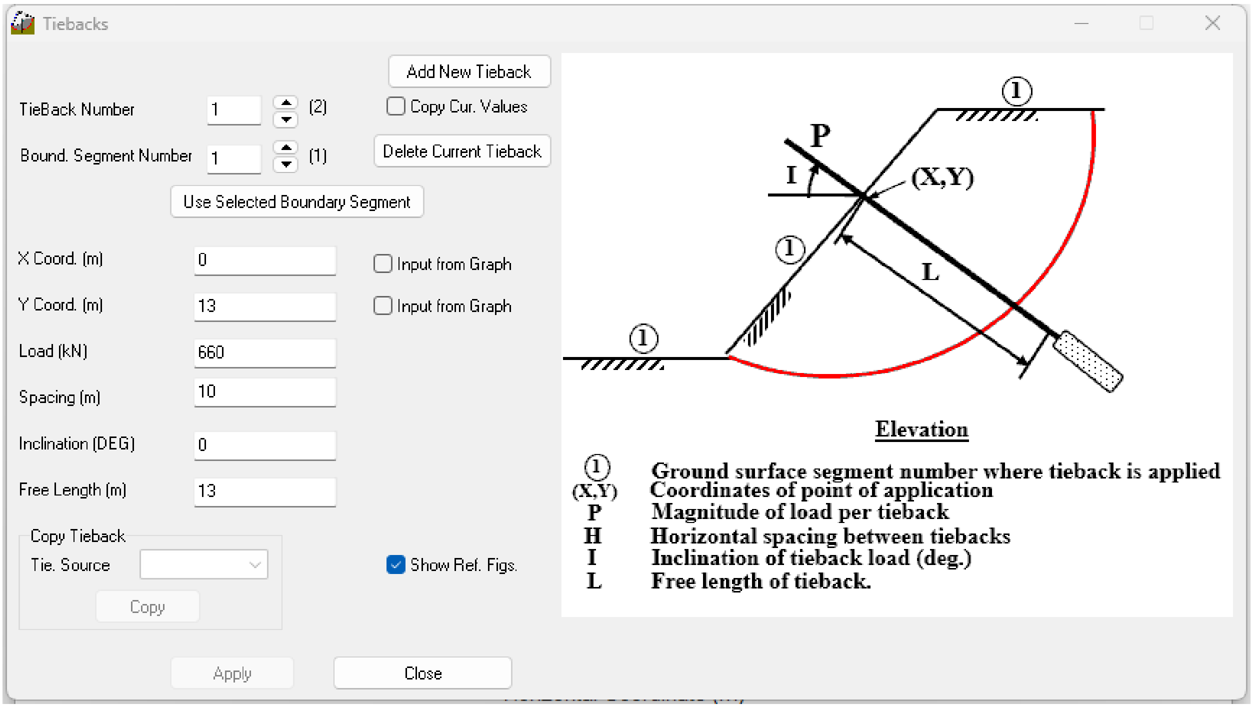

Figure 3.28 Window Tiebacks after checking on Show Rel. Figs.

3.3.12 Data –Reinforcement Layers

Program EnSlope allows the user to analyze embankments constructed on soft ground with one or more layers of reinforcement. The simplified Bishop method and the Spencer's method for circular slip surfaces can be used to consider reinforcement strips in the model. The user enters the location of each reinforcement layer, the distribution of available force, and the direction in which the force acts.

Up to 20 reinforcing layers can be specified. The location of each layer is specified by a series of x, and y coordinates starting at the left end of the reinforcement and moving to the right. In a typical application, the left end of the layer would be at the embankment toe or the face of the slope and would extend across the full width of the embankment. The coordinates of each reinforcement layer must be specified by at least 2 but not more than 40 points. The layer may be horizontal or inclined, however, the user must employ judgment on the applicability of the analysis method if the layers are more than moderately inclined. The inclination factor must be between 0.0 and 1.0. A factor of 0.0 specifies that the reinforcing force acts in the direction of the reinforcement. A factor of 1.0 specifies that the force acts tangent to the failure surface. The reinforcement force must be inputted as a positive value.

The window Reinforcement Layers will appear on the screen if Item –**Reinforced Layers** of the Input Data Menu is selected (Figure 3.29). This window allows the user to enter interactively the coordinates of the reinforced layers and/or edit reinforcement layers already defined.

Adding Reinforcement Layers

The adding reinforcement layers option will show up automatically if no reinforcement layers were defined before or after clicking on the “Add Layers” button at the left bottom corner of the Reinforcement Layers window.

There are three ways to enter a reinforced layer: Inputting the point coordinates one by one using the mouse, entering the point coordinates one by one using the entry fields, and entering the points using a table. Also, the point coordinates can be entered as a combination of the three ways listed:

1. Using the mouse

To add a point, click the mouse left button. To end a layer, click the mouse right button.

2. Using the entry fields

To add a node, enter the coordinates of the node in the X Coord and Y Coord entry fields and press the Add Node button. To end a surface, press the End Surface button.

3. Using the table

Press on the Points Table button and the Points Table will show up. Please enter the X coordinate, Y coordinate, Axial Force, Shear Force, and Inclination Factor associated with each point. Close the table using the X box on the top right corner to close the table and return to the Adding Reinforcement window. To end the layer, press the End layer button or click the right mouse button (Figure 3.30).

Notes

- As the nodes are entered, the current reinforcement will be displayed in purple color and the already defined surfaces will be displayed in maroon color as displayed in Figure 3.29.
- After adding a node, the new node number will be displayed in the Node Number field.
- After completing a layer, the new layer number will be displayed in the Layer Number field.
- As the mouse moves, the coordinates are displayed in the status bar.

To cancel the current entries on the layer, please click on the Cancel Layer button, then a prompt will appear to confirm the cancelation process. Click on Yes to confirm the cancelation; otherwise, click on No to continue defining the current layer.

Click on Close to close the window Adding Reinforcement Layers. If the current layer has not been completed, then a prompt will appear indicating that the current changes have not been completed. Click on Yes to confirm losing the latest entries; otherwise, click on No to continue defining the current layer.

By checking on the option Show Rel. Figs. The window will display a figure related to the definition of reinforcement layers (Figure 3.31).

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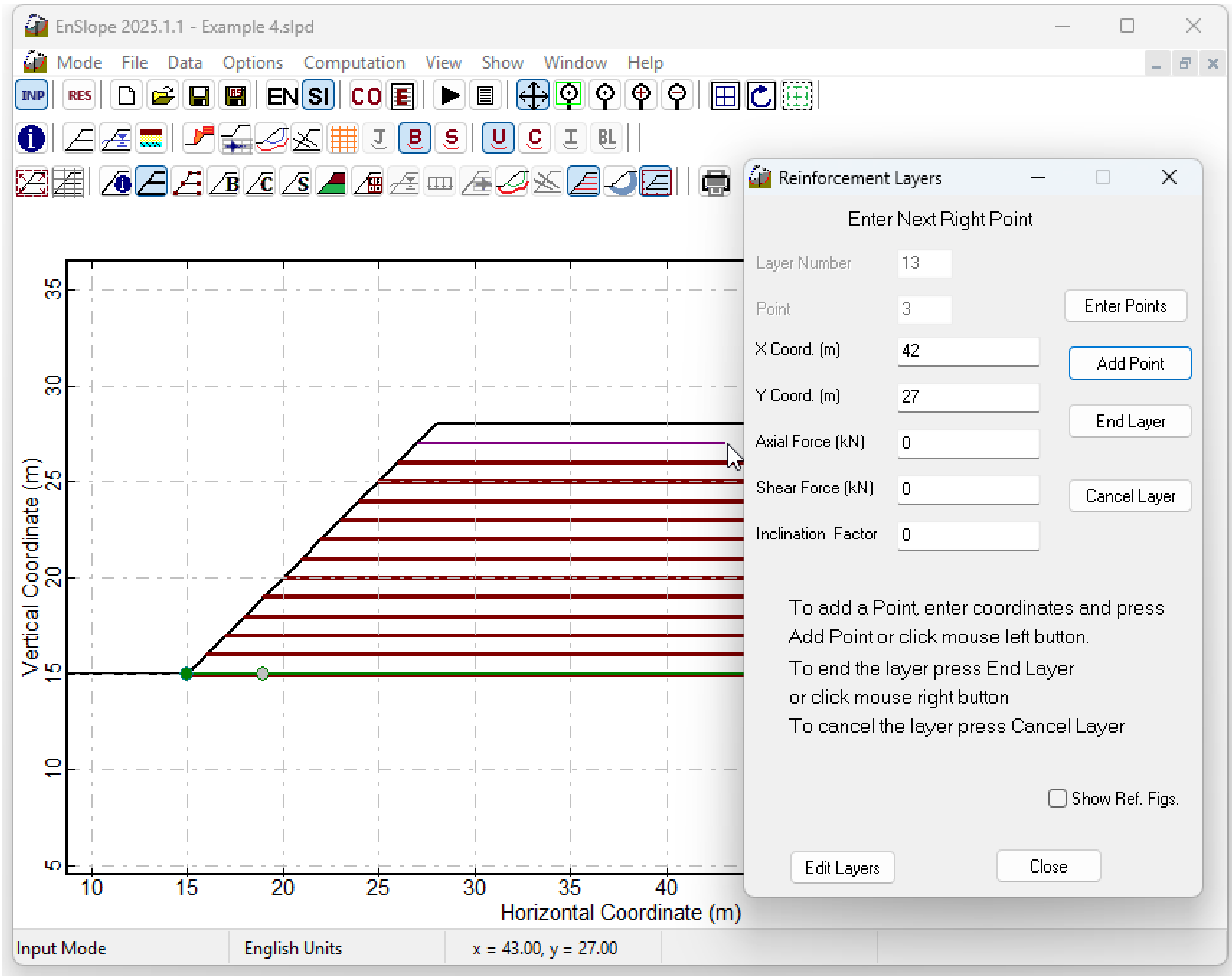

Figure 3.29 Window screen for sample Data –Reinforcement Layers

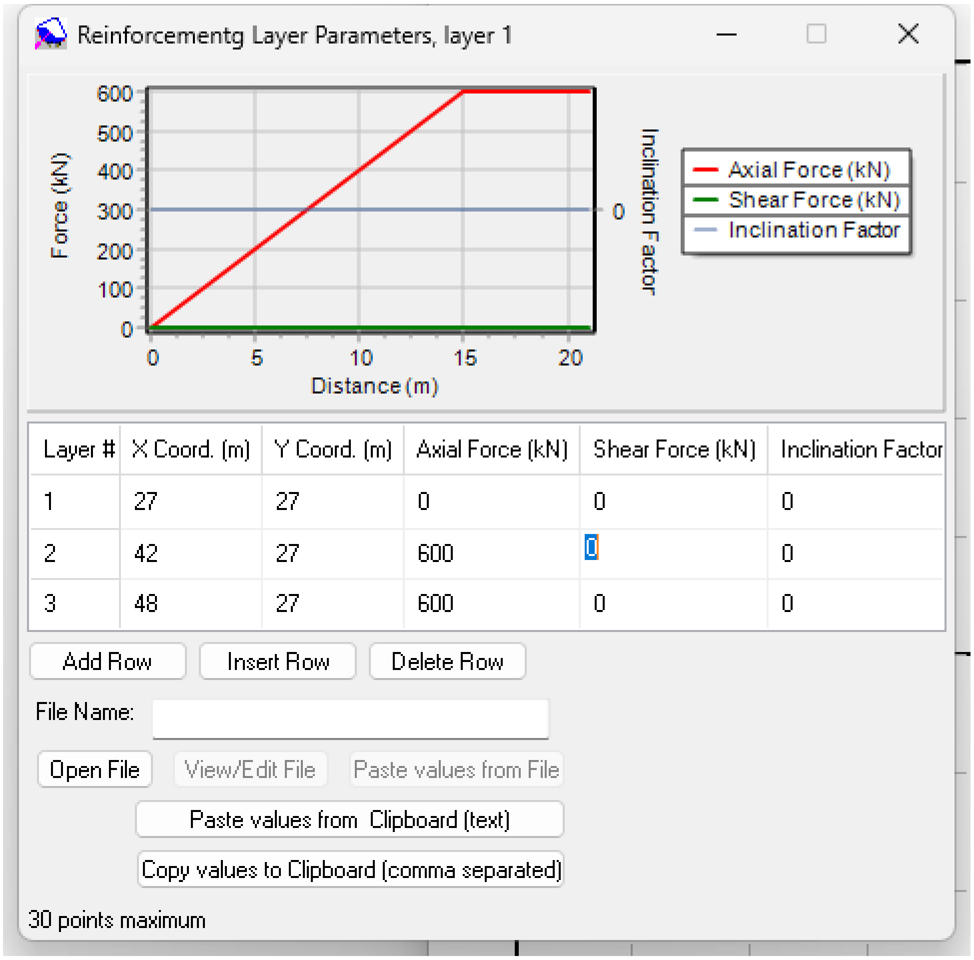

Figure 3.30 Window screen for sample Data –Reinforcement Layers – Points Table

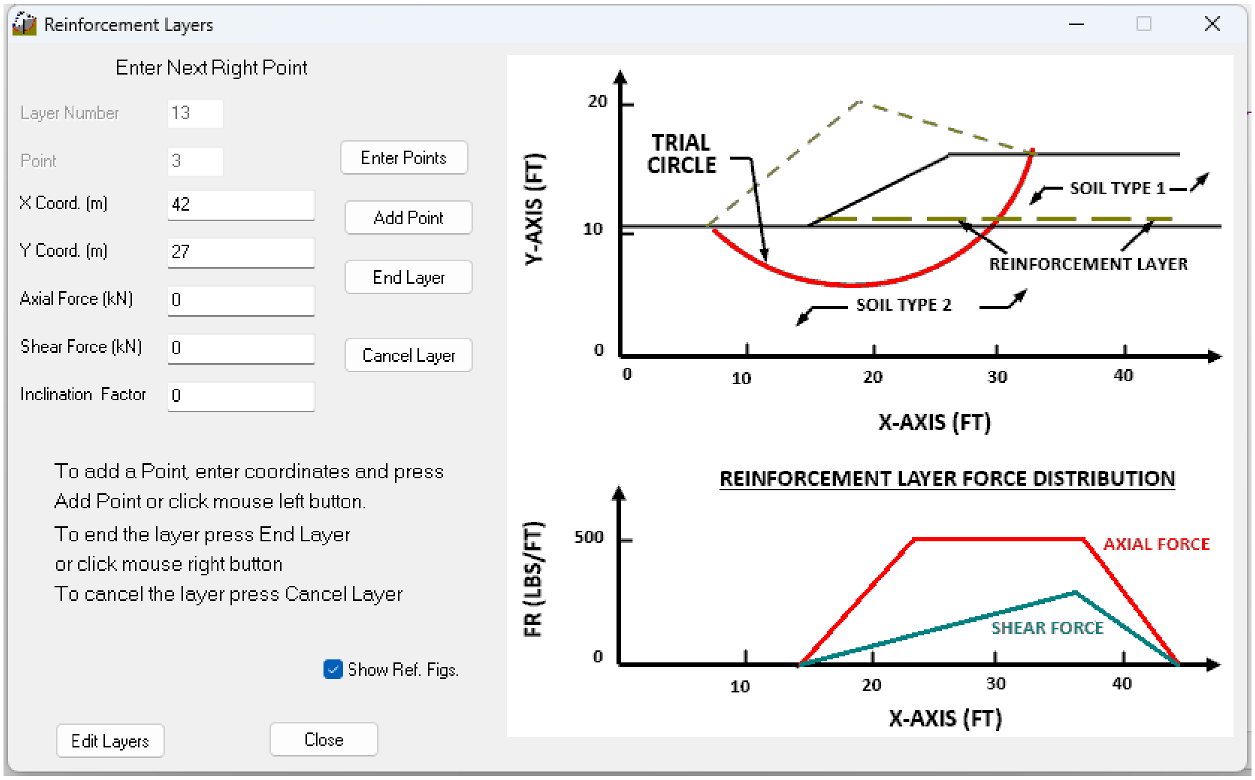

Figure 3.31 Window Reinforcement Layers after checking on Show Rel. Figs.

Editing Reinforcement Layers

The editing reinforcement layers option will show up automatically if reinforcement layers were already defined on the model or after clicking on the “Edit Layers” button at the left bottom corner of the Reinforcement Layers window. Also, the editing reinforcement layers option will show up by double-clicking over a reinforcement layer while in Input Mode.

Please note that the current layer is displayed in green color while the other segments are displayed in maroon color. For the current layer, the current node is displayed as a circle of green color while the other as circles of gray color.

Click on List Points to show and if desired edit all the points corresponding to the current layer.

Click on Update Point if wanted to change the coordinates of the current point. Please note that the Update Point button is enabled if a change has been detected to the current point coordinates.

Click on Add Point to add at the end of the layer using the given coordinates.

Click on Insert Point to insert a node after the current point using the given coordinates.

Click on Delete Point to delete the current point.

Click on Delete Reinf. L. to delete the current layer. If the **All Layers** option is checked, all the layers defined will be deleted from the model.

If desired the current layer can be copied. Please enter the number of copies and the increment in X direction and Y direction, then click on the Copy button.
Click on Close to close the window Edit Reinforcement Layers.

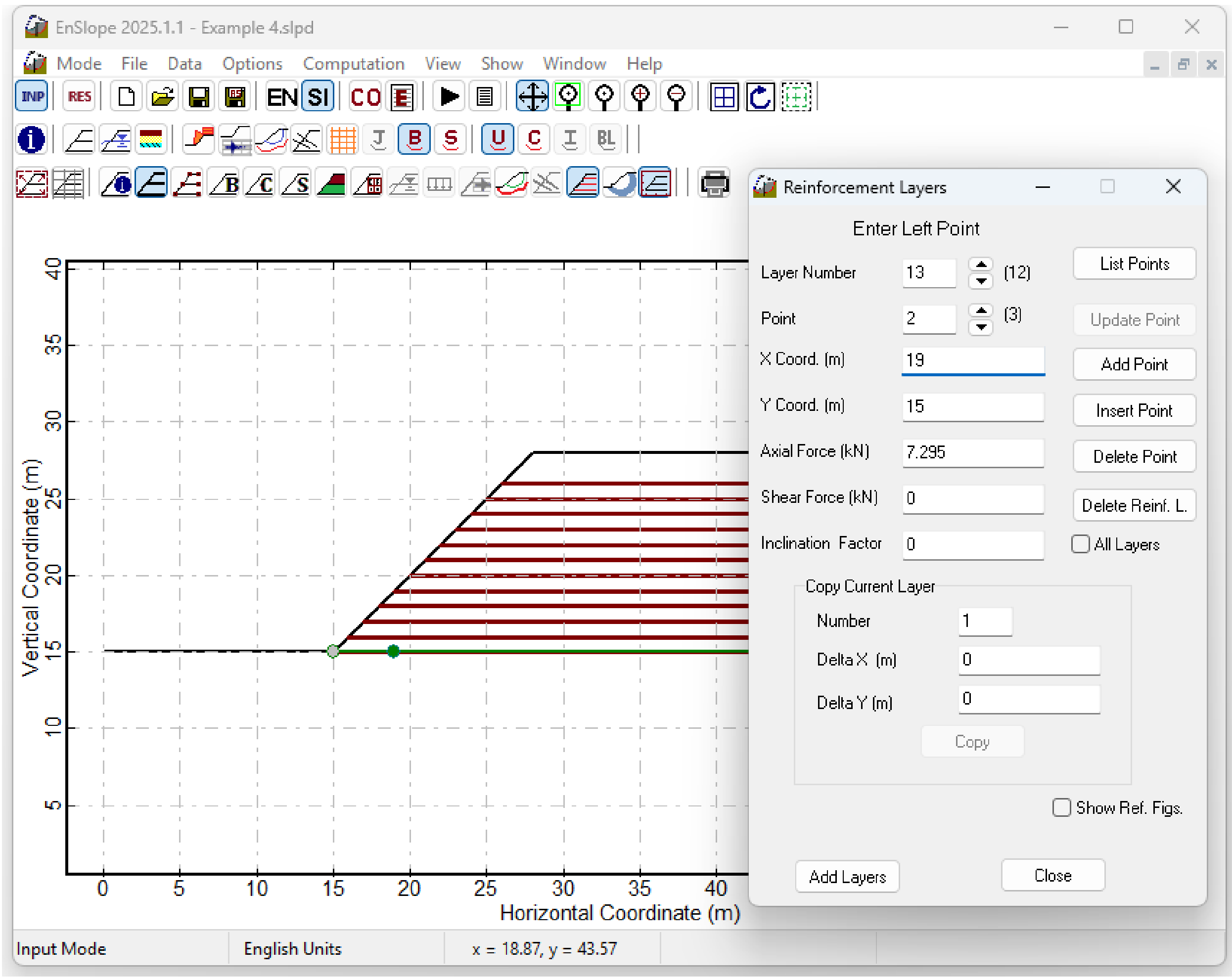

Figure 3.32 Window screen for sample Data – Reinforcement Layers (editing option)

3.3.13 Data – Method of Analysis

Three different methods of analyzing the stability of a slope are available for use in EnSlope. To specify the method of analysis to use, the user must first select Item **Method of Analysis** from the Data menu, as shown in Figure 3.33.

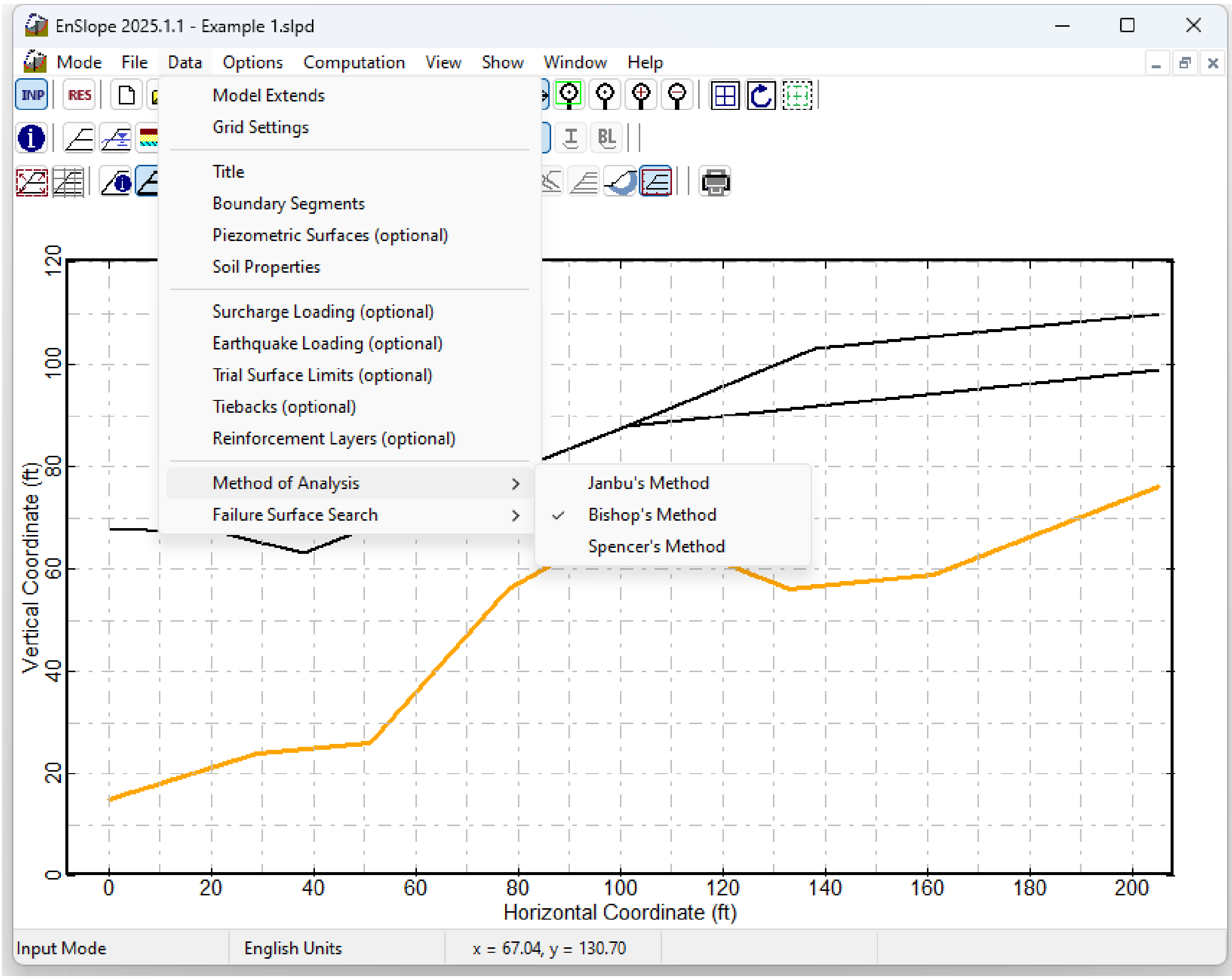

Figure 3.33 Window screen for sample Data – Method of Analysis

The three methods of analysis available in EnSlope are (1) Janbu’s method, (2) Bishop’s method, and (3) Spencer’s method.

Janbu’s Method

EnSlope can use the Simplified Janbu method of slices to analyze the stability of the slope.

To choose Janbu’s method, select the subitem **Janbu’s Method** under the Item –**Method of Analysis** of the Data Menu. It can be used for user-defined failure surfaces, and for generated failure searches using circular, or irregular block procedures. Janbu’s method cannot be used for slopes with Reinforcement Layers.

Bishop’s Method

EnSlope can use the Simplified Bishop method of slices to analyze the stability of the slope.

To choose the Bishop’s method, select the subitem **Bishop’s Method** under the Item –**Method of Analysis** of the Data Menu. It can be used for user-defined failure surfaces, and for generated failure search using circular procedures. Bishop’s method can be used for slopes with Reinforcement Layers.

Spencer's Method

EnSlope can use the Spencer method of slices to analyze the stability of the slope.

To choose Spencer's method, select the subitem **Spencer's Method** under the Item –**Method of Analysis** of the Data Menu. It can be used for user-defined failure surfaces, and for generated failure searches using circular, or irregular block procedures. Spencer's method can be used for slopes with Reinforcement Layers.

Since significantly more computation time is required for the analysis of potential failure surfaces using Spencer's method of slices than either the Simplified Janbu or Simplified Bishop methods, the most efficient use of the EnSLope capabilities will be realized if the user first investigates many potential failure surfaces using one of Enslope random surface generation techniques which determines the factor of safety using either the Simplified Janbu or Simplified Bishop method of slices. Once critical potential failure surfaces have been identified, they may be analyzed using the Spencer option to obtain a factor of safety (FOS) satisfying both force and moment i.e., complete equilibrium.

When a user-input potential failure surface is analyzed, the program outputs include (1) the value of the factor of safety for force equilibrium (Ff), (2) the value of the factor of safety for moment equilibrium (Fm), (3) the angle of the interslice forces (theta) calculated during iteration, (4) the values of FOS and theta satisfying complete equilibrium, (5) the coordinates of the line of thrust, (6) the ratio of the height of the line of thrust above the sliding surface to the slice height for each slice, and (7) the values of the interslice forces.

3.3.14 Data – Failure Surface Search

Program EnSlope features unique random techniques for the generation of potential failure surfaces for subsequent determination of the more critical surfaces and their corresponding factors of safety. One technique generates circular failure surfaces, and another technique generates more general irregular surfaces of random shapes. The user may also specify a predetermined failure surface for the computation of the factor of safety.

To specify the failure surface method to use, the user must select Item **Failure Surface Search** from the Data menu, as shown in Figure 3.34.

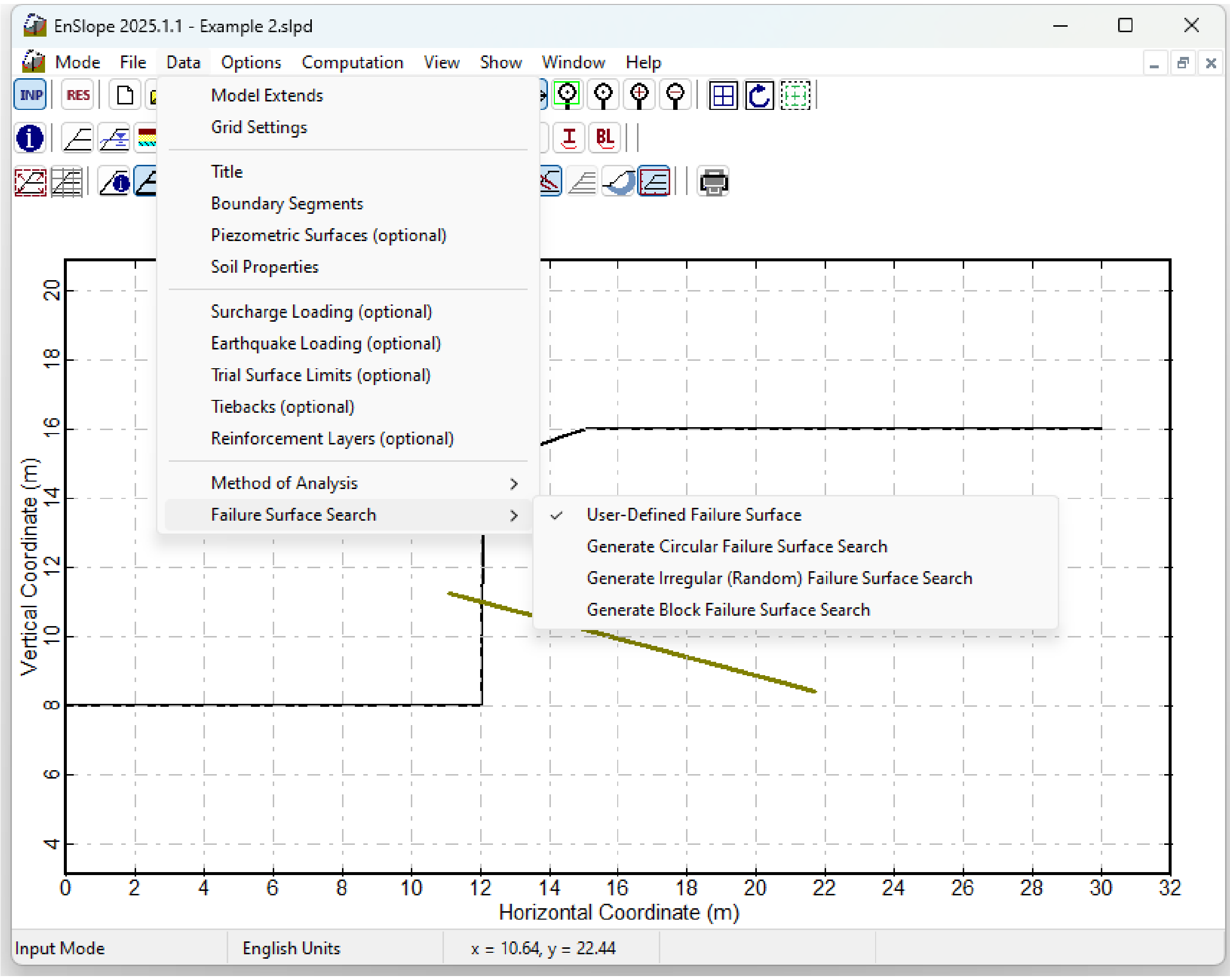

Figure 3.34 Window screen for sample Data – Failure Surface Search

The various types of searches for failure surfaces are discussed in the following sections.

User-Defined Failure Surface

Program EnSlope allows the user to specify a predefined failure surface. The Janbu, and Spencer methods can be used with any user-defined failure surface. The Bishop method can be used only with circular user-defined failure surface

The window User-Defined Failure Surface will appear on the screen if the Subitem –**User-Defined Failure Surface** of the Failure Surface Search Item of the Data Menu is selected (Figure 3.35). Please note that if the User-Defined Failure Surface was already defined as a search type, the window Edit User-Defined Failure Surface will show up. Please see the Edit Data section – Failure Surface Search Controls for details about that window. This window allows the user to enter interactively the coordinates of the user-defined failure surface and/or edit a user-defined failure surface already defined.

The User-Defined Failure Surface can be defined as a polyline or as a circular.

Polyline Option

- Adding Polyline

The adding polyline failure surface option will show up automatically if no user-defined failure surface was defined before.

If the polyline option is selected, the user can enter interactively the coordinates of the user-defined failure surface. There are three ways to enter a user-defined failure surface: inputting the node coordinates one by one using the mouse, entering the node coordinates one by one using the entry fields, and entering the nodes using a table. Also, the node coordinates can be entered as a combination of the three ways listed:

1. Using the mouse

To add a node, click the mouse left button. To end a surface, click the mouse's right button.

2. Using the entry fields

To add a node, enter the coordinates of the node in the X Coord and Y Coord entry fields and press the Add Node button. To end a surface, press the End Surface button.

3. Using the table

Press on the Nodes Table button and the Nodes Table will show up. Please enter the X, and Y coordinates. Close the table using the X box on the top right corner to close the table and return to the

Adding User-Defined Failure Surface window. To end the surface, press the End Surface button or click the right mouse button.

Notes

- As the nodes are entered, the current user-defined failure surface will be displayed in teal color and the already defined surface will be displayed in gray color as displayed in Figure 3.35.
- After adding a node, the new node number will be displayed in the Node Number field.
- After completing a surface, the new surface number will be displayed in the Surface Number field.
- As the mouse moves, the coordinates are displayed in the status bar.
- A total of 20 points may be used to define the failure surface.

To cancel the current entries on the surface, please click on the Cancel Surface button, then a prompt will appear to confirm the cancelation process. Click on Yes to confirm the cancelation; otherwise, click on No to continue defining the current surface.

If Spencer's method is used, the Interslice Angle should be entered.

Click on Close to close the window User-Defined Failure Surface. If the current surface has not been completed, then a prompt will appear indicating that the current changes have not been completed. Click on Yes to confirm losing the latest entries; otherwise, click on No to continue defining the current surface.

Click on Consider as Circular Surface, if the polyline defined must be considered as circular. This option must be checked if the Bishop method is used for analysis.

By checking on the option Show Rel. Figs. The window will display a figure related to the definition of a user-defined failure surface (Figure 3.36).

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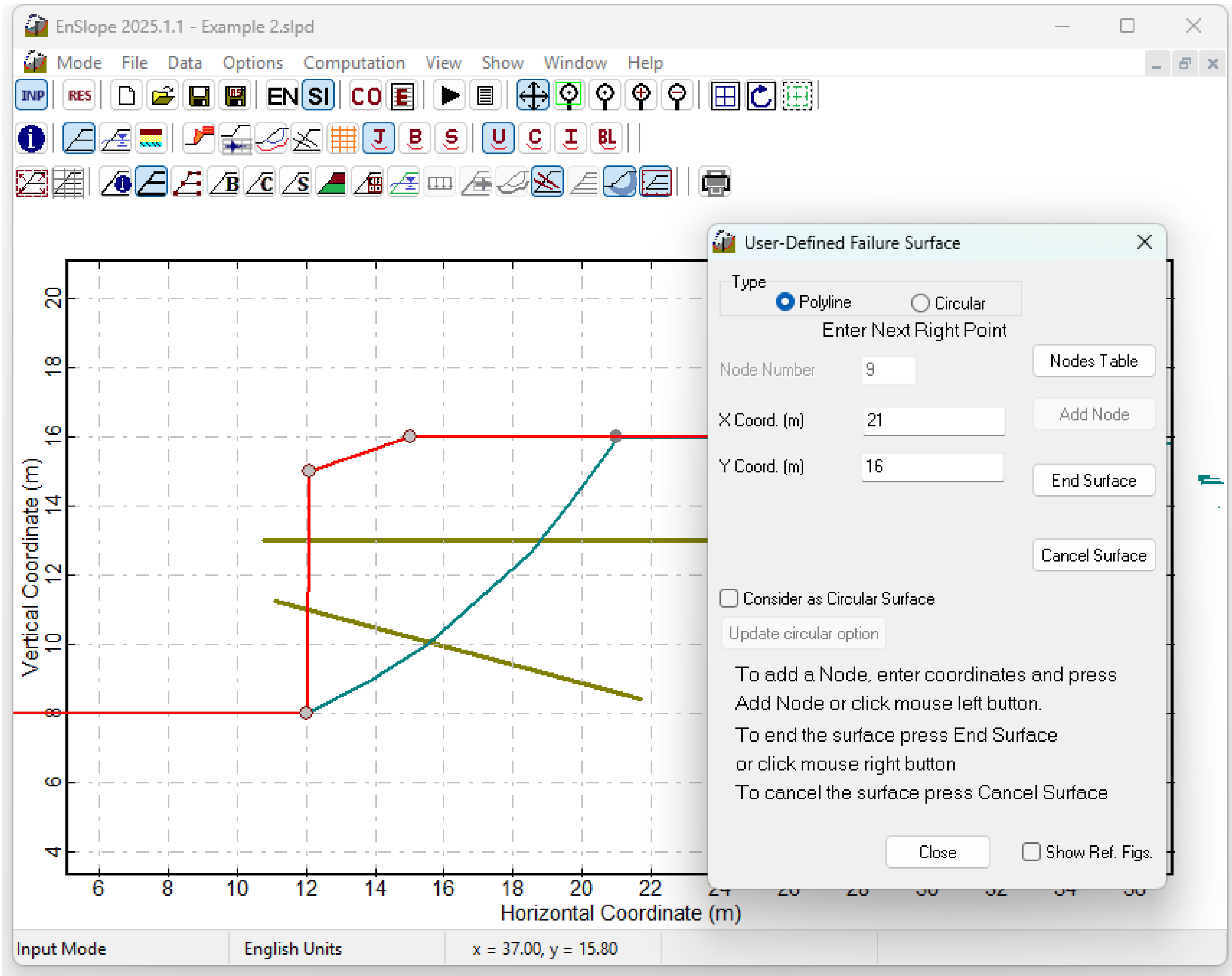

Figure 3.35 Window screen for sample Data –Failure Surface Search - User-Defined Failure Surface, Polyline Option

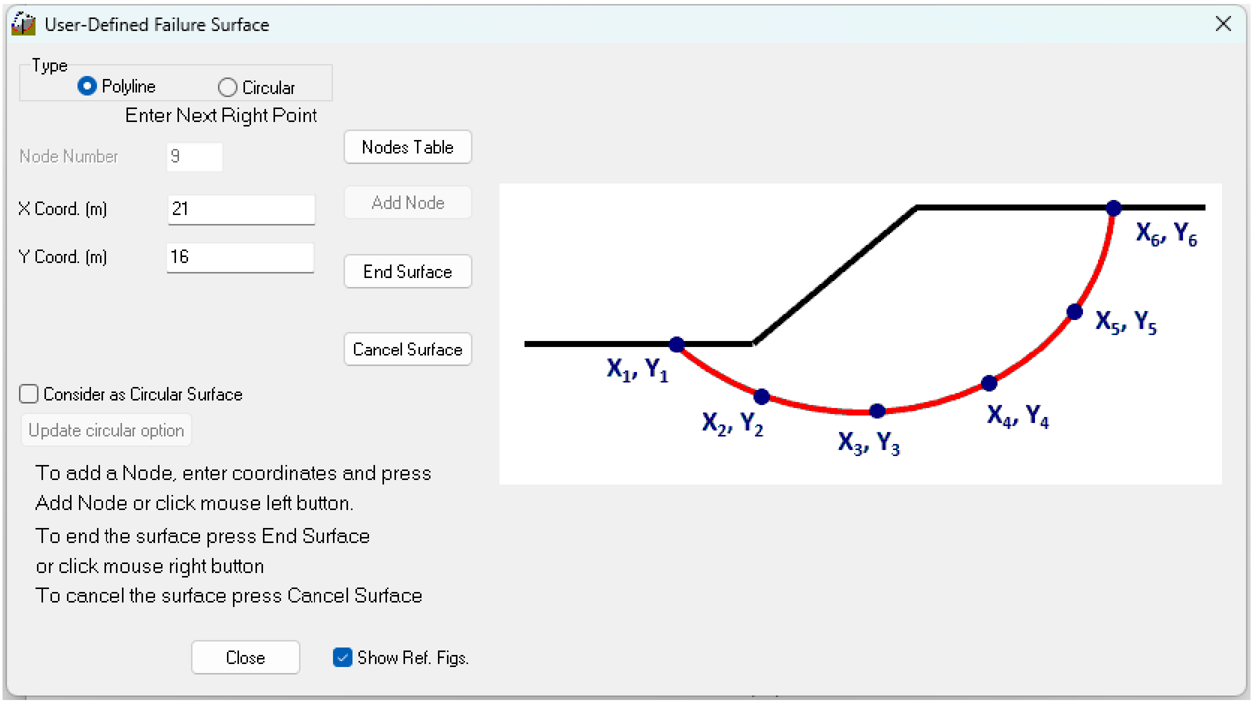

Figure 3.36 Window Adding User-Defined Failure Surface Limits, Polyline Option, after checking on Show Rel. Figs.

- Editing Polyline

The editing polyline failure surface option will show up automatically if the user-defined failure surface (polyline) was defined before. Also, the editing polyline failure surface option will show up by double-clicking over the user-defined failure surface while in Input Mode.

Please note that the failure surface is displayed in red color. The current node is displayed as a circle of maroon color while others as circles of gray color.

Click on List Nodes to show and if desired edit all the nodes corresponding to the current surface.

Click on Update Node if wanted to change the coordinates of the current node. Please note that the Update Node button is enabled if a change has been detected to the current node coordinates.

Click on Add Node to add at the end of the surface using the given coordinates.

Click on Insert Node to insert a node after the current node using the given coordinates.

Click on Delete Node to delete the current node.

Click on Delete Surface to delete the current surface.

Click on Close to close the window Edit User-Defined Failure Surface.

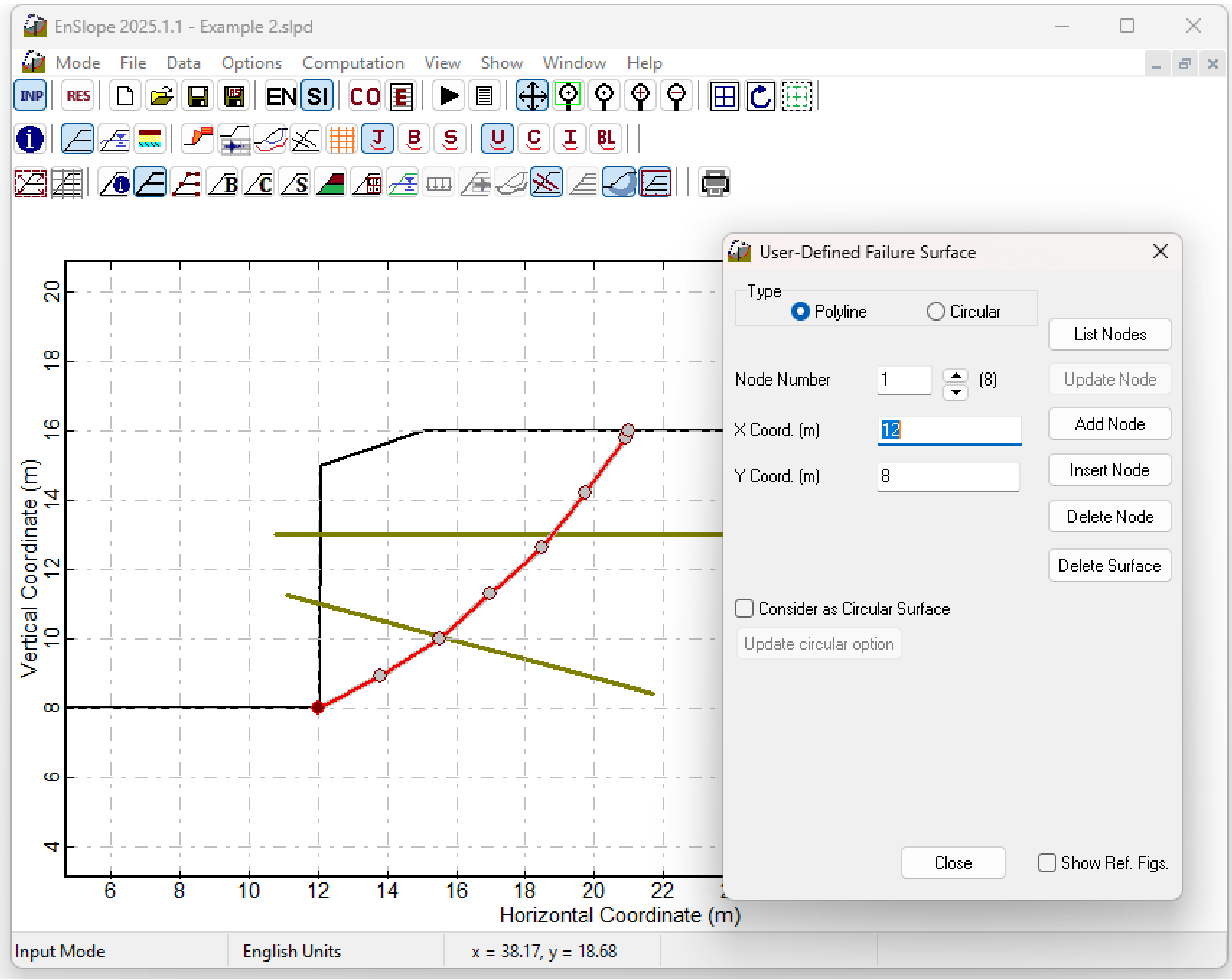

Figure 3.37 Window screen for sample User-Defined Failure Surface Window, Polyline Option (editing)

Circular Option

If the circular option is selected, the user can enter interactively the variables to define the circular surface in three ways: using 2 points and radius, using center and radius, or using 3 points:

1. Using 2 Points and Radius

Enter the coordinates (X and Y) of the Left Point and Right Point and enter the Radius of the Circle. As the coordinates are entered the program will try to draw the circular surface being defined. If desired the user can get the coordinates (or radius) from the graph by clicking the mouse if the Get … option is checked. If Get Left is checked the Left Point coordinate can be extracted, if Get Right is checked the Right Point coordinate can be extracted, and if Get Radius is checked the Radius can be extracted based on the position of the mouse (Figure 3.38).

2. Using Center and Radius

Enter the coordinates (X and Y) of the Center Point and enter the Radius of the Circle. As the coordinates are entered the program will try to draw the circular surface being defined. If desired the user can get the coordinates (or radius) from the graph by clicking the mouse if the Get … option is checked. If Get Center is checked the Center Point coordinate can be extracted, and if Get Radius is checked the Radius can be extracted based on the position of the mouse (Figure 3.39).

3. Using 3 Points and Radius

Enter the coordinates (X and Y) of the Left Point, Right Point, and Middle Point. As the coordinates are entered the program will try to draw the circular surface being defined. If desired the user can get the coordinates (or radius) from the graph by clicking the mouse if the Get … option is checked. If Get Left is checked the Left Point coordinate can be extracted, if Get Right is checked the Right Point coordinate can be extracted, and if Get Mid is checked the Middle Point can be extracted (Figure 3.40).

Notes

- As the nodes are entered, the current surface will be displayed in blue color and the already-defined surface will be displayed in gray color as displayed in Figure 3.38.
- As the mouse moves, the coordinates are displayed in the status bar.
- The user should enter the number of segments to divide the circular surface in the Segment entry.
- If a Get … option is checked the program will pass to the next Get … option after getting the variable from the graph by clicking the mouse.

If Spencer’s method is used, the Interslice Angle should be entered.

To save the changes to the current circular surface Click on Apply to keep the Adding User-Defined Failure Surface Window open or Save and Close to save the changes and close the window.

By checking on the option Show Rel. Figs. The window will display a figure related to the definition of a user-defined failure surface (Figure 3.41).

Please note that the user-defined circular failure surface option will show up by double-clicking over the user-defined circular failure surface while in Input Mode

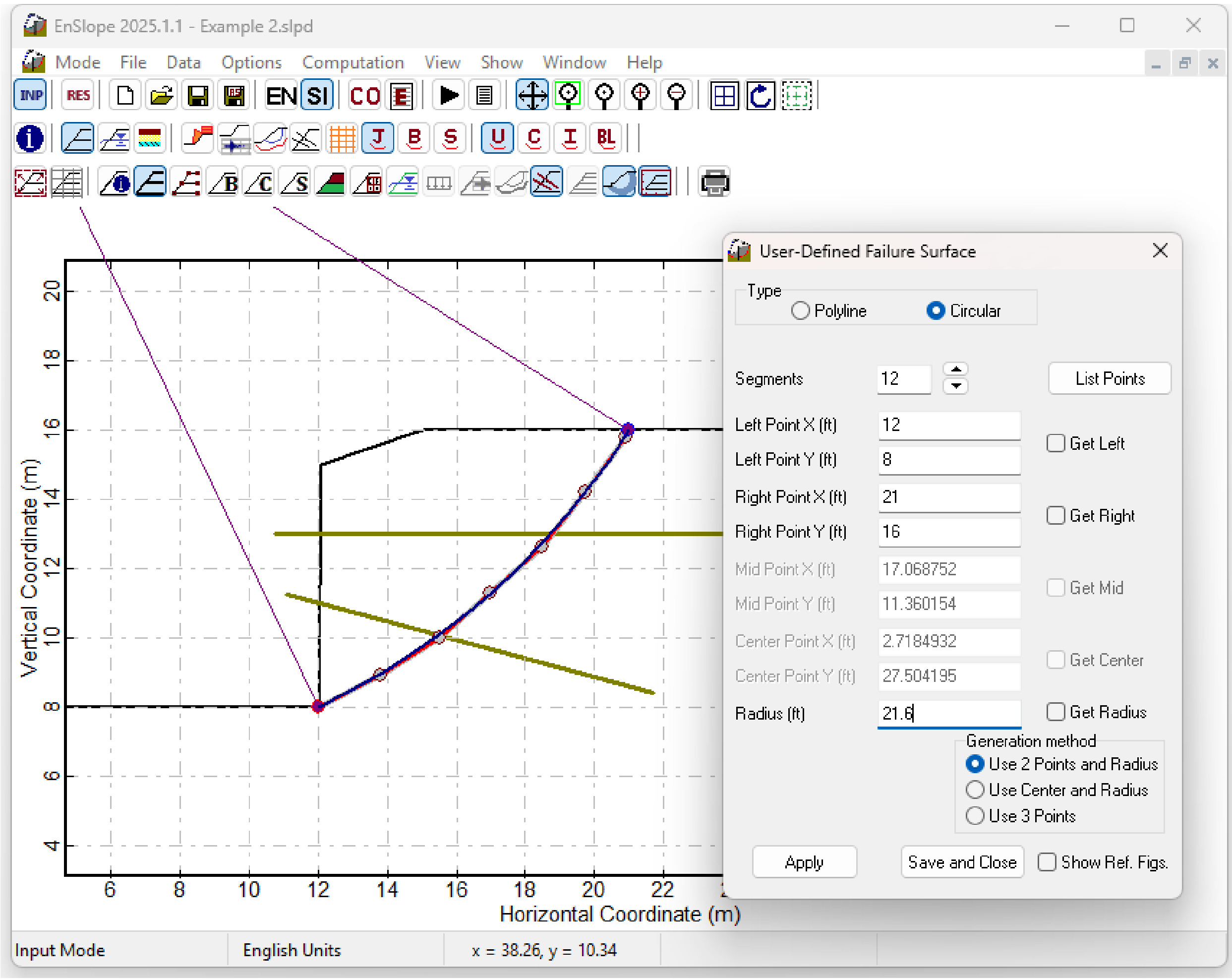

Figure 3.38 Window screen for sample Data – Failure Surface Search - User-Defined Failure Surface, Circular Option, Using 2 Points and Radius

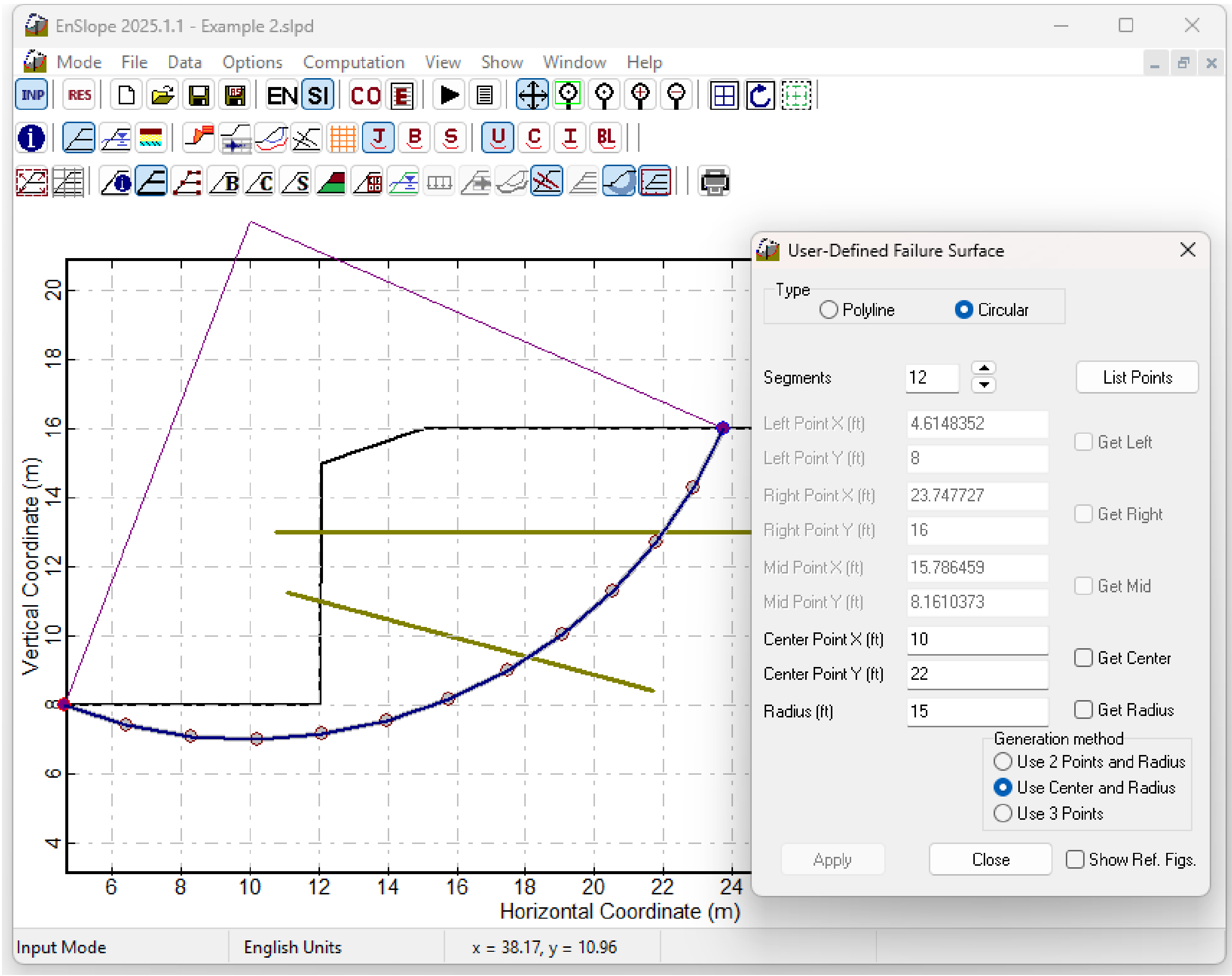

Figure 3.39 Window screen for sample Data – Failure Surface Search - User-Defined Failure Surface, Circular Option, Using Center and Radius

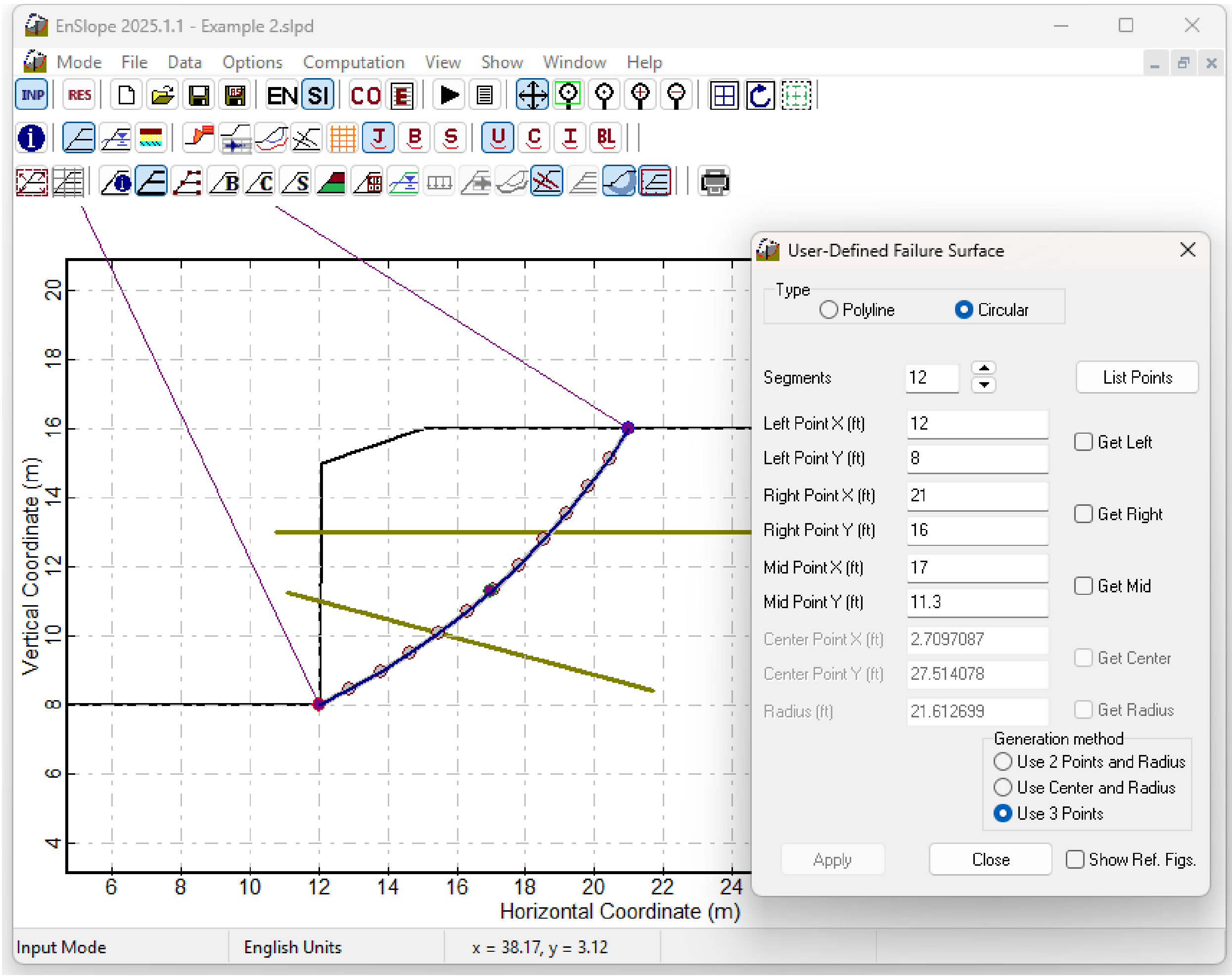

Figure 3.40 Window screen for sample Data –Failure Surface Search - User-Defined Failure Surface, Circular Option, Using 3 Points

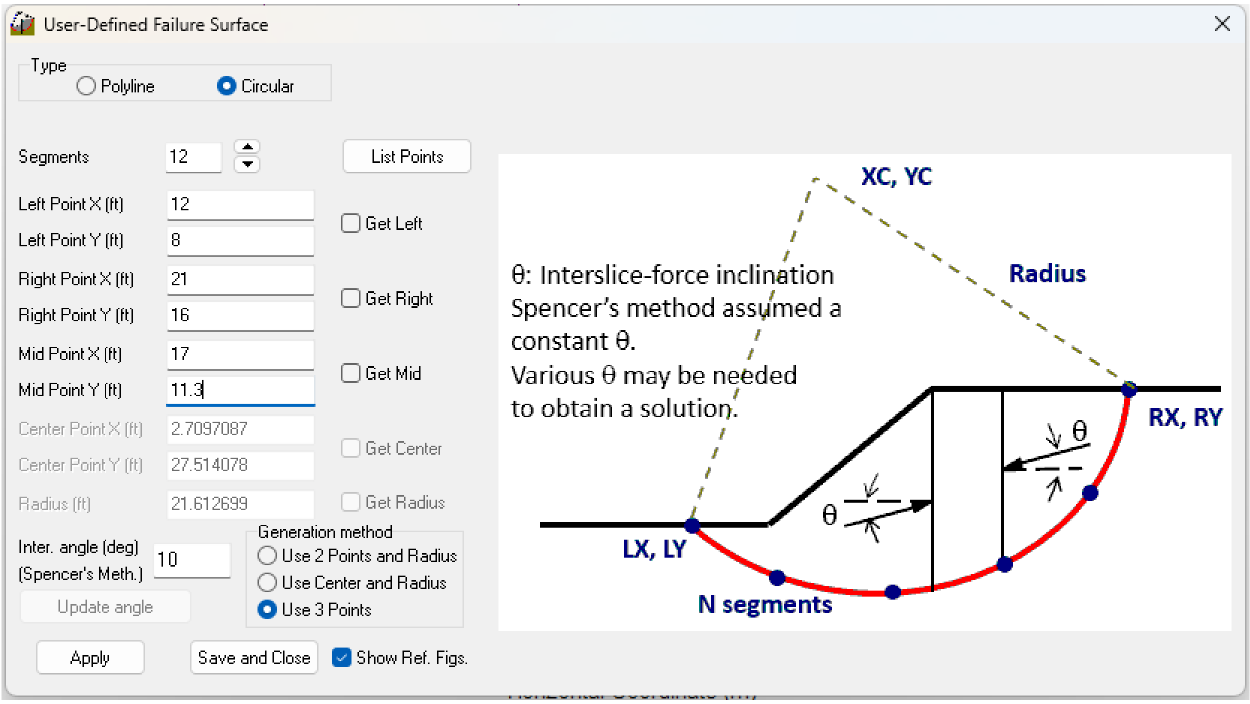

Figure 3.41 Window Adding User-Defined Failure Surface Limits, Circular Option, after checking on Show Rel. Figs. (using Spencer Method)

Generate Circular Failure Surface Search

Program EnSlope can use procedures to search for circular failure surfaces. Janbu, Bishop, and Spencer's methods can be used with circular failure surface search.

The window Circular Failure Surface Search will appear on the screen if Item –**Generate Circular Failure Surface Search** of the Failure Surface Search Sub-item of the Data Menu is selected (Figure 3.42). Please note that the circular failure surface window will show up by double clicking over the objects: left points, right points, or minimum elevation while in Input Mode.

The geometrical data required by the program can be easily interpreted by the user with the graphical presentation. A detailed description of the variables is given on the screen. The graphical sketch on the screen will help the user to visualize the definition of the variables. If desired the user can get the coordinates (or elevation) from the graph by clicking the mouse if the Get option to the right of the entry is checked.

If Spencer's method is used, the Interslice Angle should be entered.

To save the changes to the current circular search click on Apply to keep the Circular Failure Surface Search Window open or Save and Close to save the changes and close the window.

By checking on the option Show Rel. Figs. The window will display a figure related to the definition of circular search (Figure 3.43).

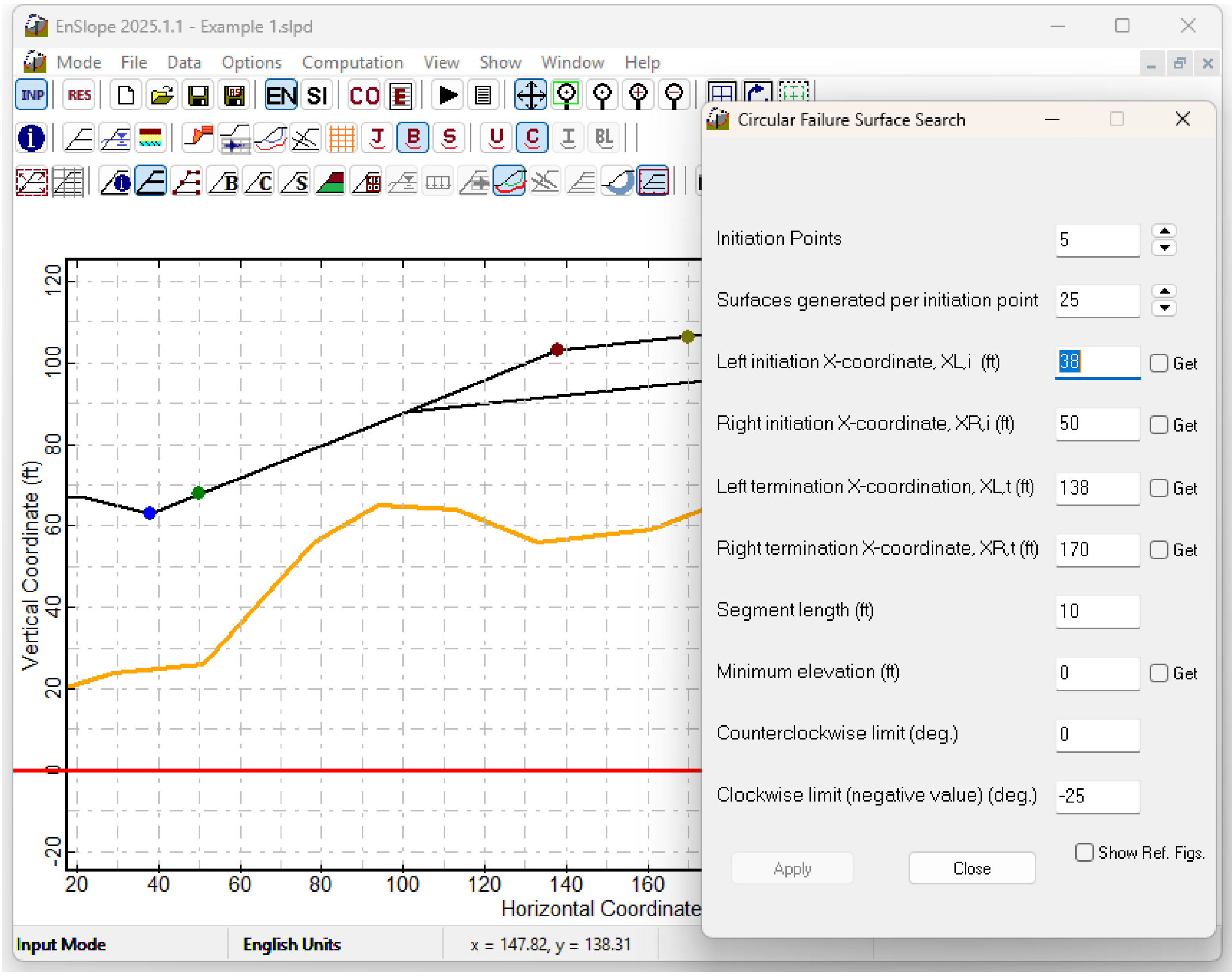

Figure 3.42 Window screen for sample Data –Failure Surface Search - Generate Circular Failure Surface Search

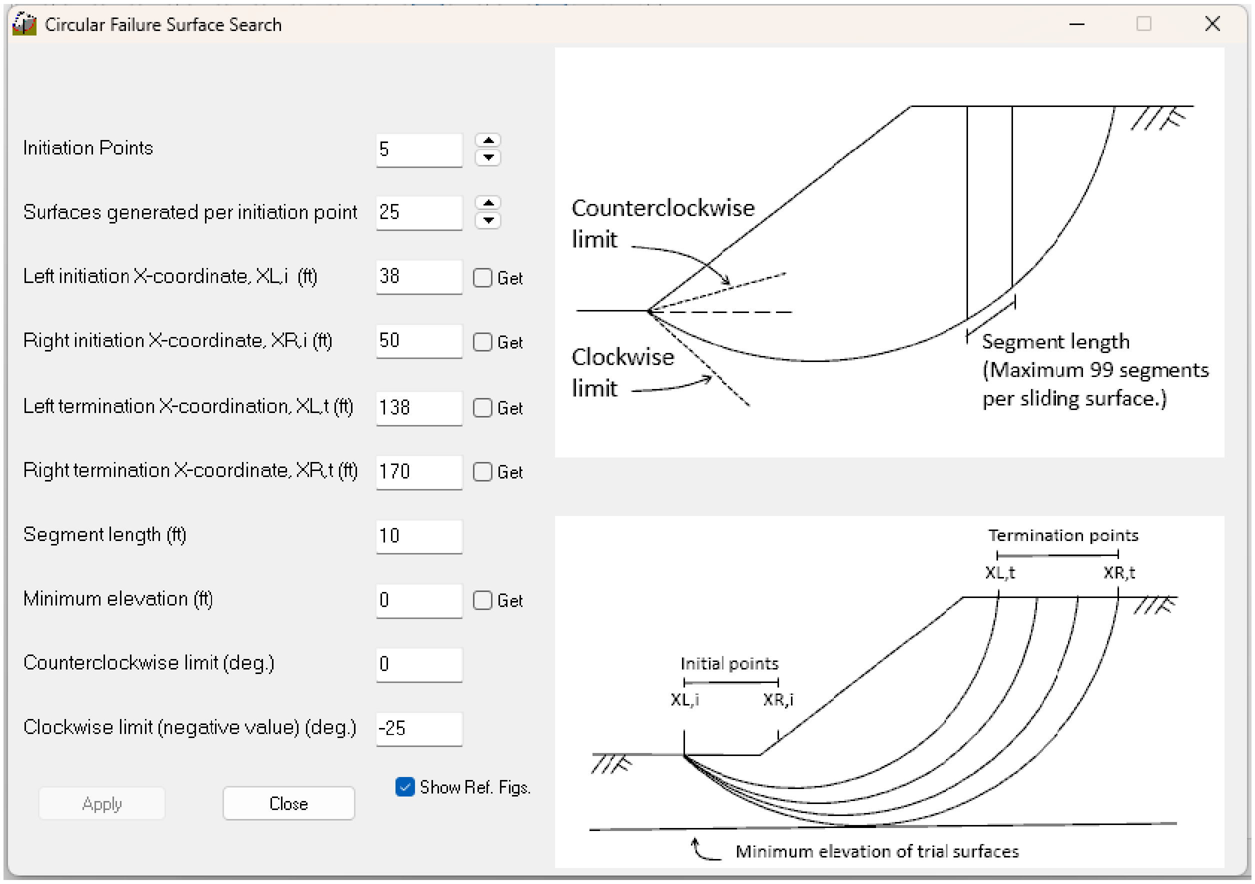

Figure 3.43 Window Circular Failure Surface Search after checking on Show Rel. Figs.

Generate Irregular (Random) Failure Surface Search

Program EnSlope can use procedures to search for irregular failure surfaces. Janbu and Spencer methods can be used with irregular failure surface search.

The window Irregular (Random) Failure Surface Search will appear on the screen if Item –**Generate Irregular (Random) Failure Surface Search** of the Failure Surface Search Sub-item of the Data Menu is selected (Figure 3.42). Please note that the irregular failure surface window will show up by double clicking over the objects: left points, right points, or minimum elevation while in Input Mode

The geometrical data required by the program can be easily interpreted by the user with the graphical presentation. A detailed description of the variables is given on the screen. The graphical sketch on the screen will help the user to visualize the definition of the variables. If desired the user can get the coordinates (or elevation) from the graph by clicking the mouse if the Get option to the right of the entry is checked.

If Spencer's method is used, the Interslice Angle should be entered.

To save the changes to the current irregular search click on Apply to keep the Irregular Failure Surface Search Window open or Save and Close to save the changes and close the window.

By checking on the option Show Rel. Figs. The window will display a figure related to the definition of irregular search (Figure 3.43).

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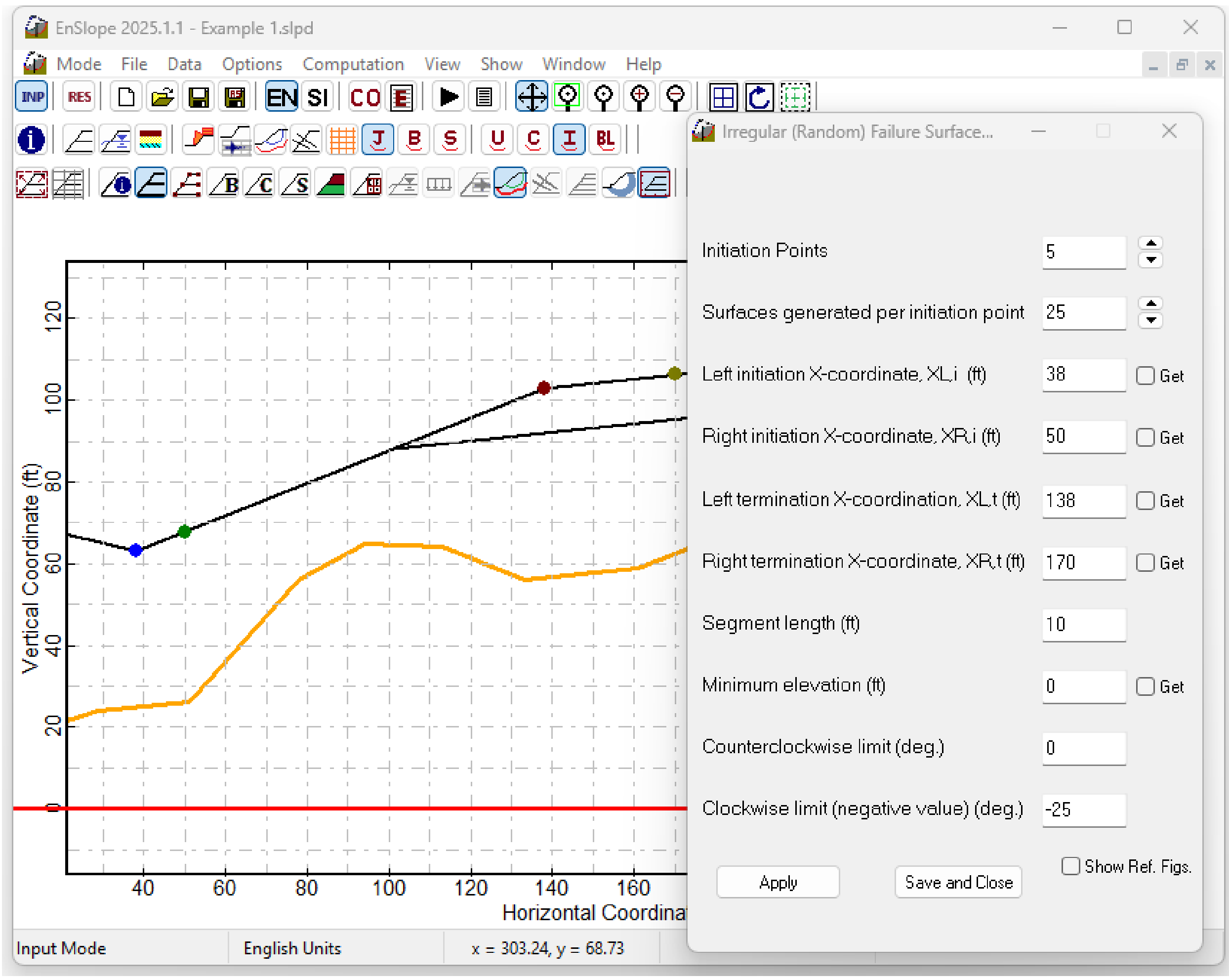


Figure 3.44 Window screen for sample Data –Failure Surface Search - Generate Irregular (Random) Failure Surface Search

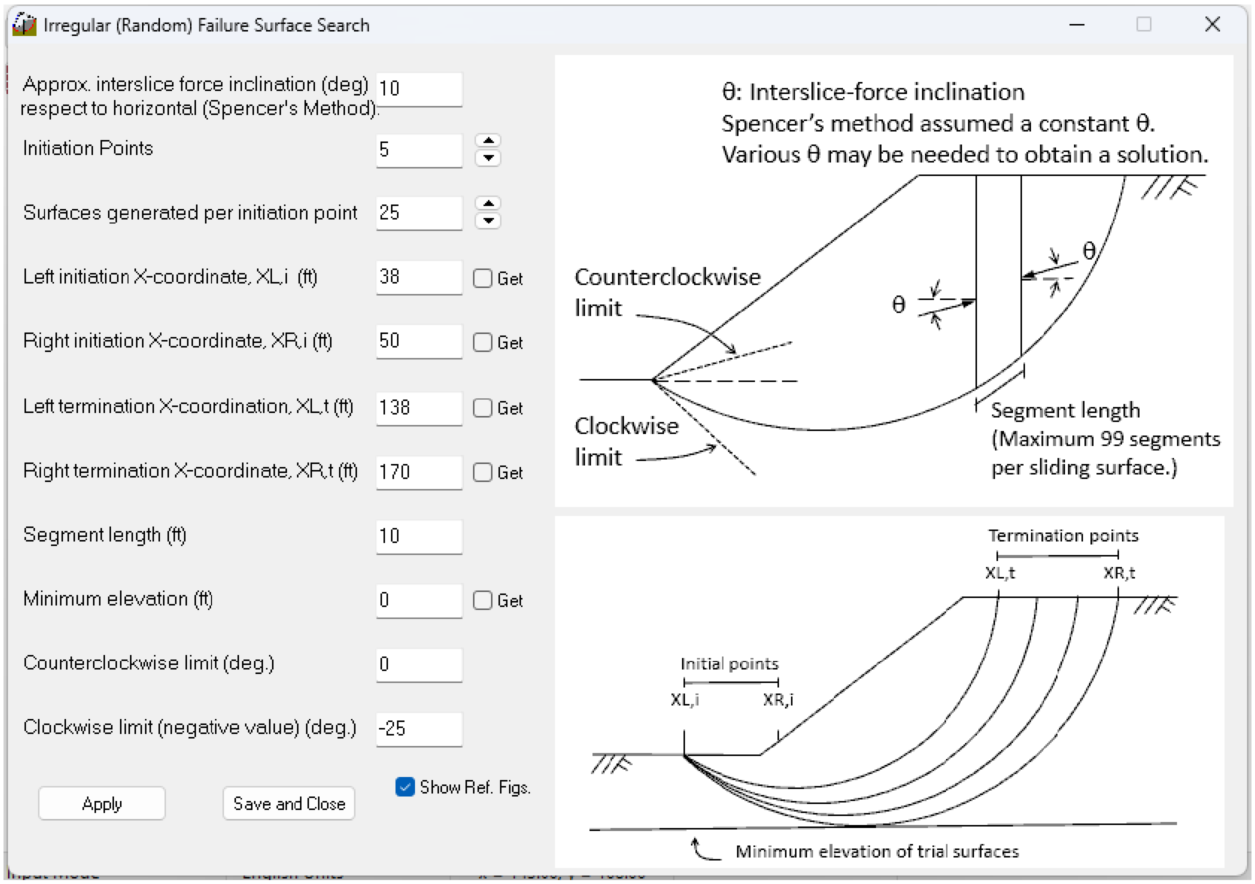


Figure 3.45 Window Irregular (Random) Failure Surface Search after checking on Show Rel. Figs. (using Spencer method)

<u>**Generate Block Failure Surface Search**</u>

Program EnSlope can use Rankine's theory to generate the surface of a sliding block. Janbu and Spencer's methods can be used with block failure surface search.

The window Search by Block Method will appear on the screen if Item – **Generate Block Failure Surface Search** of the Add Failure Surface Search Sub-item of the Input Data Menu is selected (Figure 3.46). Please note that the block failure surface window will show up by double-clicking over the block objects defining the block surface search while in Input Mode.

The geometrical data required by the program can be easily interpreted by the user with the graphical presentation. A detailed description of the variables is given on the screen. The graphical sketch on the screen will help the user to visualize the definition of the variables. If desired the user can get the coordinates (or vertical side length) from the graph by clicking the mouse if the Get option to the right of the entry is checked.

If Spencer's method is used, the Interslice Angle should be entered.

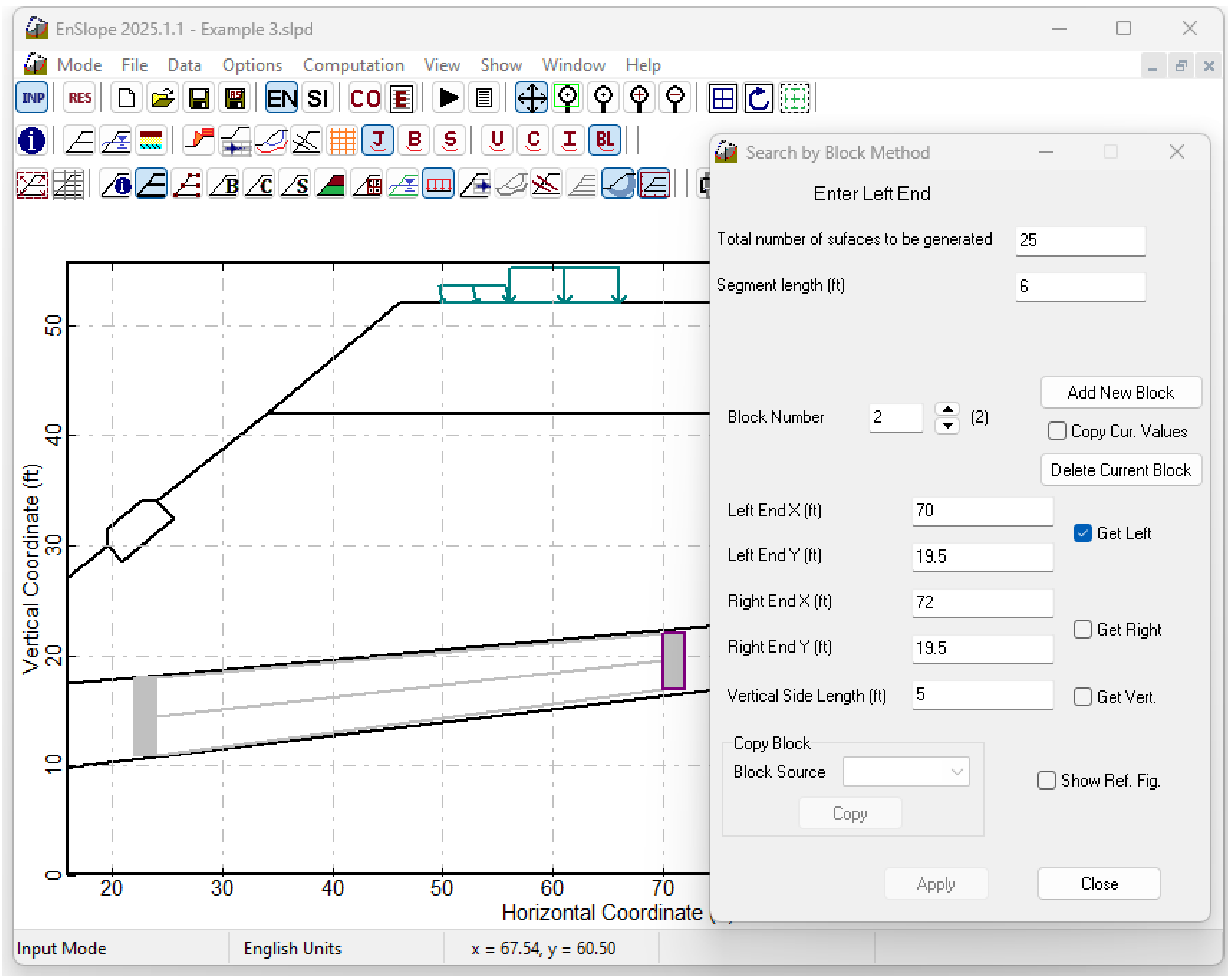


Figure 3.46 Window screen for sample Data – Failure Surface Search – Generate Block Failure Surface Search

Please note that the block already defined is displayed in gray color. The current block being defined is displayed in purple color.

To save the changes to the current block Click on Apply to keep the Adding Search by Block Method Window open or Save and Close to save the changes and close the window. After saving the changes, Click on Add Block to define a new block.

By checking on the option Show Rel. Figs. The window will display a figure related to the definition of the search by block method (Figure 3.47).

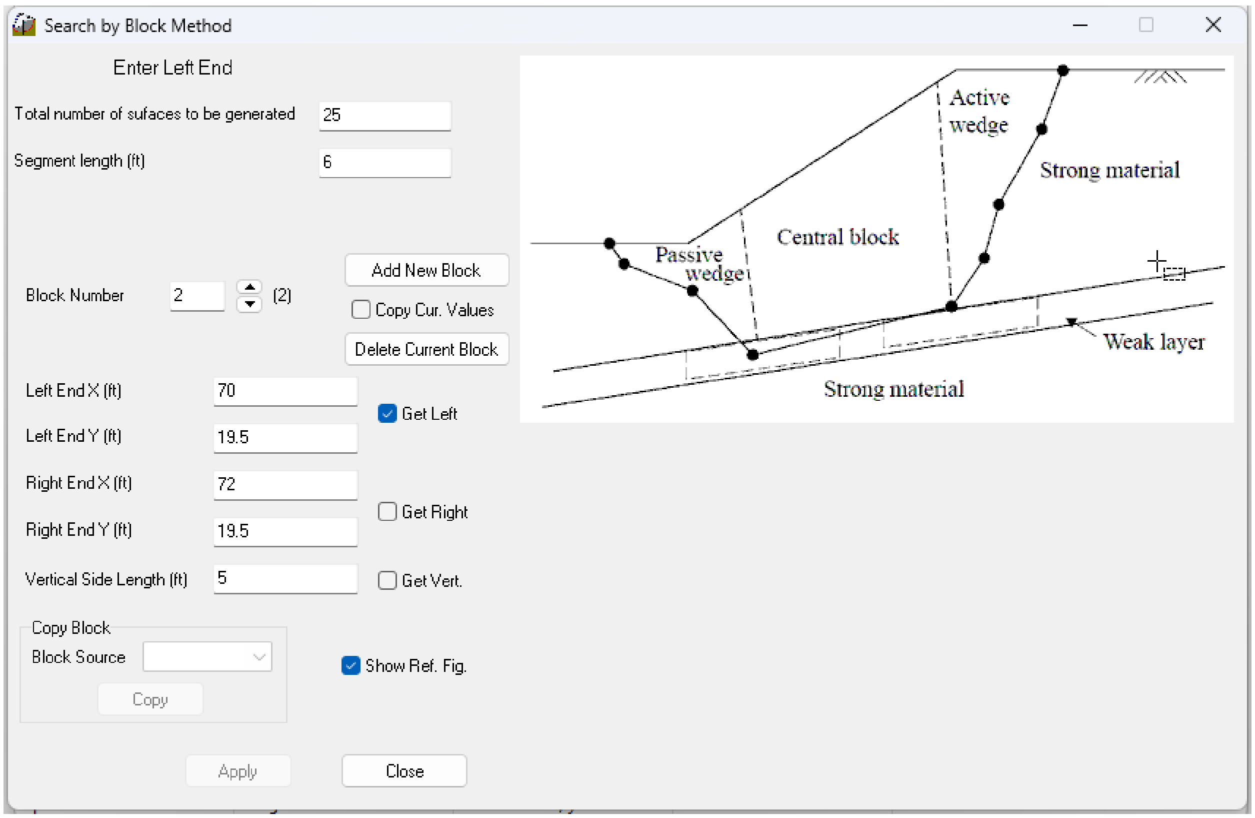


Figure 3.47 Window Search by Block Method, after checking on Show Rel. Figs.

3.4 Options Menu

3.4.1 Options - Units

This selection provides the user with a choice of input data in English Units, and S.I. Units (international units) as shown in Figure 3.48. In general, the following specific units of measurement are used frequently in the program:

Units	**Length**	**Force**	**Stress/Modulus**
English	foot (ft)	pounds (lbs)	psf
International	meters (m)	kiloNewtons (kN)	kPa

The user should always check the unit descriptions which are associated with each variable in the program interface. The user may change from one system of units to the other as many times as desired. The program will automatically convert all the appropriate input that was already specified by the user before the time of selection of a different system of units. Small conversion errors may appear if multiple changes of units are performed. The user must always check that the input data has been converted appropriately.

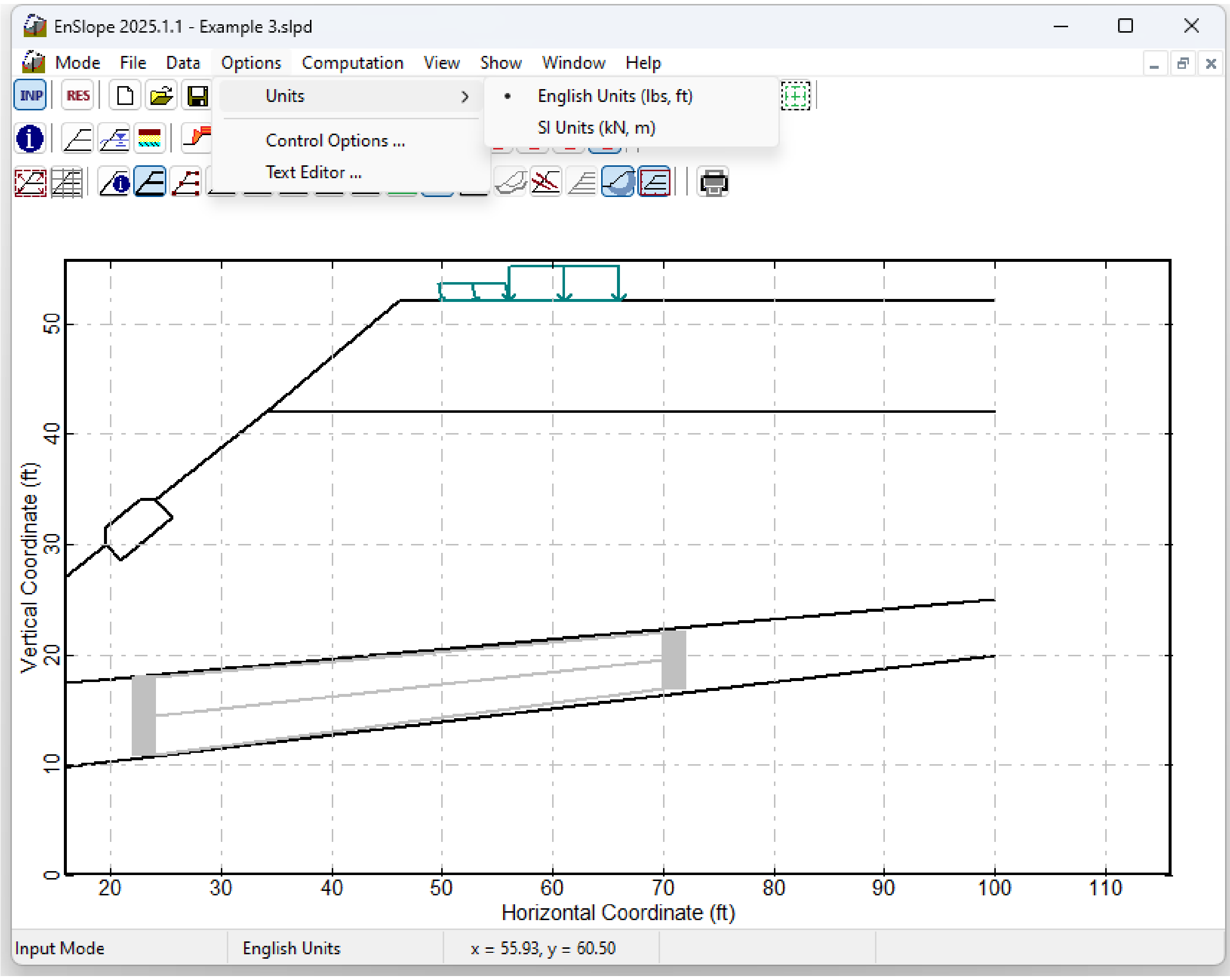


Figure 3.48 Options for Unit Selection

3.4.2 Options – Control Options

This option allows the user to change the default criteria convergence. (Figure 3.49). Default options may work for most of the models, but for some cases user may need to change the default values to improve convergence or to do some parametric studies.

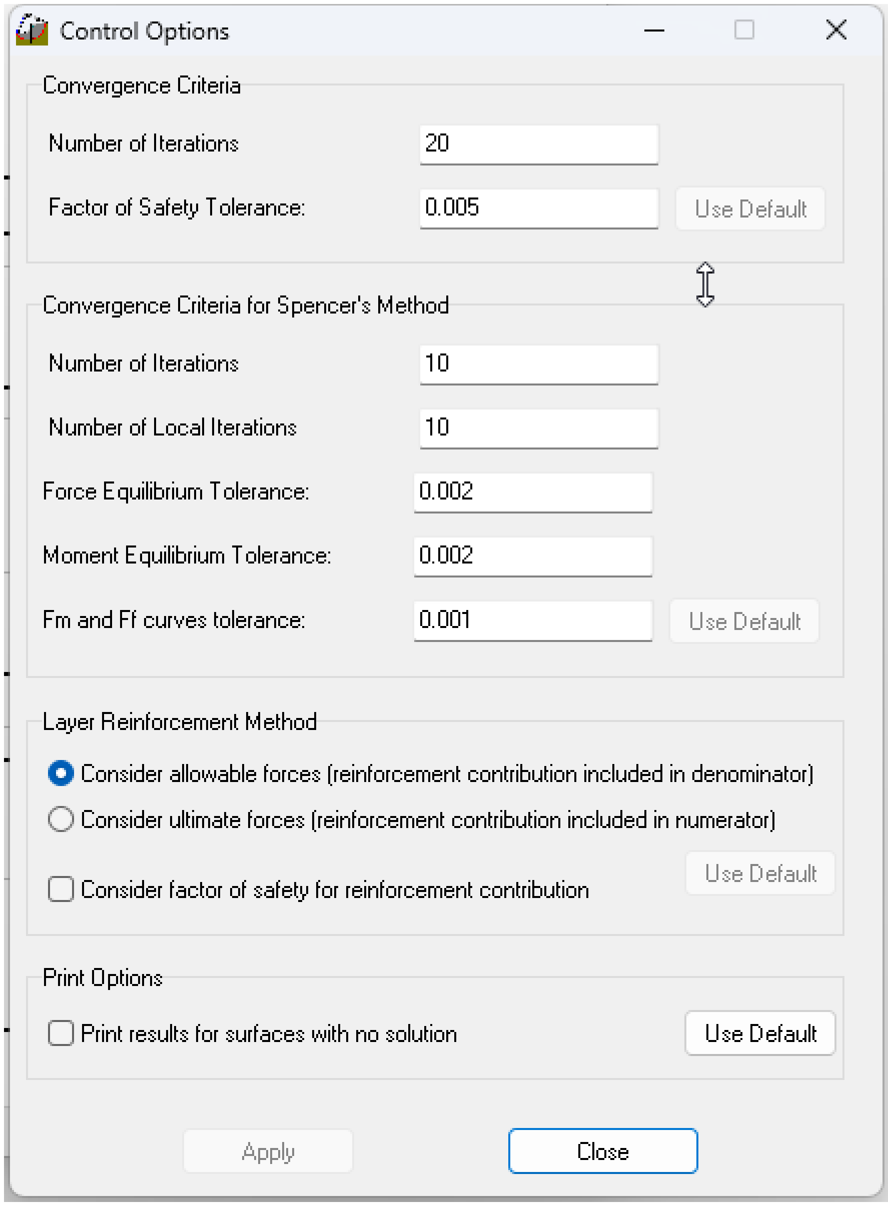


Figure 3.49 Options – Control Options

3.4.3 Options – Text Editor

The user should input in this box (Figure 3.50) the complete path and command line for the preferred text editor or word processor that will be used to examine and print the input, output, and the processor run notes files created by the EnSlope program.

As a default, the command line *c:\windows\notepad.exe* is used to operate a standard text editor. Microsoft Notepad is included with Microsoft Windows 7, 8, 10 and 11. However, the path to the directory where *notepad.exe* is installed varies in different versions of the Microsoft Windows operating system.

There may be some instances when the output files are too large for Notepad and a different text editor or word processor should be used. In those cases, it is suggested to use Microsoft WordPad (*c:\windows\wordpad.exe*).

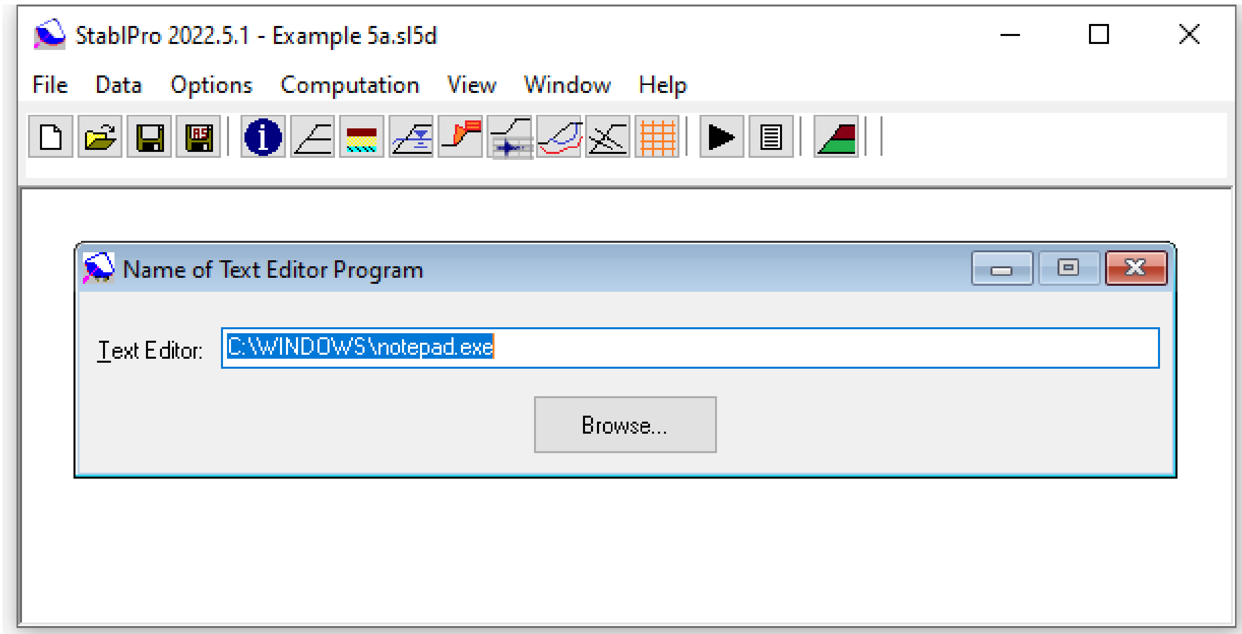
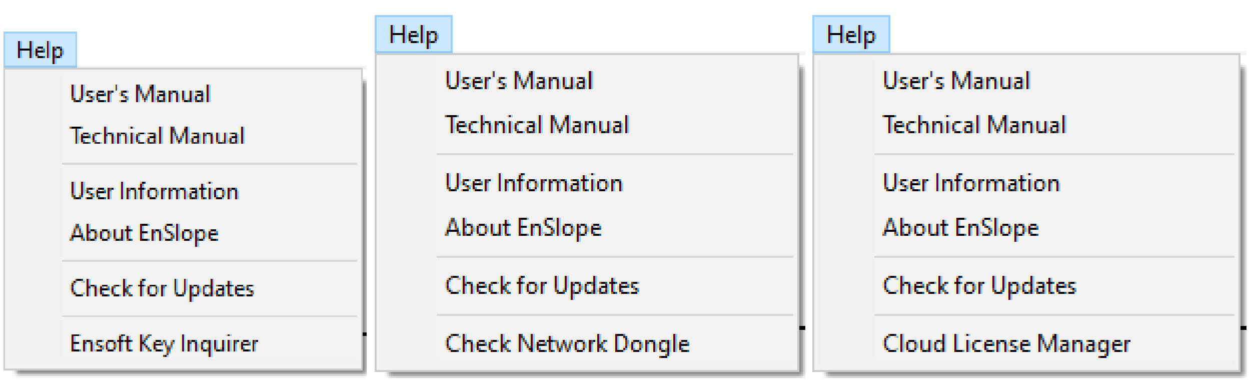


Figure 3.50 Options – Text Editor

3.5 Help Menu

This menu allows for access to two manuals that are installed with EnSlope: User's Manual, and Technical Manual. All manuals are copyrighted and also protected against modifications or copying of its content. These manuals are distributed in standard PDF files and should be available for any PDF reader that is installed in the user's computer.

The Help menu, shown in Figure 3.51, also provides access to slightly different utilities/information according to the type of license that is installed in each computer. The various entries in the Help menu are described below.



a. Single-User License b. Client on Local Network License c. Cloud Subscription License

Figure 3.51 Help Menu

3.5.1 User's Manual

The Help > User's Manual calls the default PDF-file reader that is installed in the user's computer and opens the PDF file of the EnSlope User's Manual. The User's Manual for EnSlope is contained in the *EnSlope2025UsersManual.pdf* file that is installed with the program.

3.5.2 Technical Manual

The Help > Technical Manual calls the default PDF-file reader that is installed in the user's computer and opens the PDF file of the EnSlope Technical Manual. The Technical Manual for EnSlope is contained in the *EnSlope2025TechnicalManual l.pdf* file that is installed with the program.

3.5.3 About EnSlope

This command provides a dialog describing the program version, date, and methods for accessing technical support. Other information about the program licensing and maintenance expiration date, program version, and program release date are also shown. A sample of this dialog box is provided in Figure 3.52.

3.5.4 Check for Updates

The Help > Check for Updates submenu will start up the default Internet browser and report the user of the current program version and maintenance expiration date as well as any new update that is available for downloading from Ensoft's website (*www.ensoftinc.com*). Users shall be able to download, install and run, in full mode and without the intervention from Ensoft, any EnSlope program release/update that was made prior to their maintenance expiration date. Notice that some anti-virus programs may require the user to grant permission to EnSlope to open the Internet browser program.

3.5.5 User Information

In this entry, the user may enter any information that personalizes their EnSlope installation. This information is requested when the user first runs the program and can be modified at any time afterwards using this dialog box. A sample of this dialog box is provided in Figure 3.53.

The information in this entry is included near the beginning of all output files that are generated by this particular installation of EnSlope. The first sections of a sample output file is provided in Figure 3.54.

3.5.6 Ensoft Key Inquirer

This submenu is only available on single-user installations of the software product (it is not available for users running a network version of the product). This utility is used to check for licensing information on the USB Key that is connected to a working USB port of the computer in use. It provides information such as serial number, maintenance expiration date, etc. This utility is also necessary for a remote update and renewal of the license for this product. This utility is installed in the selected installation directory with the following filename: *ensoft_key_inquirer_v5.exe* (may change with time).

3.5.7 Check Network Dongle

This submenu is only available on client computers of network versions of the software product (it is not available for users running a single-user version of the product). This utility helps to check the licensing and to troubleshoot communications with a license manager (or software server). This utility is very useful in case of problems in clients while trying to run the licensed software. This utility is installed in the selected installation directory with the following filename: *CheckNetworkDongle_ipv_511.exe* (may change with time).

3.5.8 Cloud License Manager

This is only available on cloud subscription installations of the software product (it is not available for users with USB Key based installations, such as single-user or network licenses). A sample dialog screen for this utility is shown in Figure 3.55.

The Account tab allows to Logout so as to prevent other users of this computer from logging into EnSlope with the same Ensoft Cloud user account. After a Logout, starting the program, or running new computations or saving a file will require a new Ensoft Cloud account login procedure with the required <username> and <password>.

The License tab allows users to Checkout Seat for a specified period of time (Duration) in order to be able to use the license without internet access (this is also referenced as 'hard checkout' of a license). By default, the maximum Duration is limited to 15 days by Ensoft. However, the account 'Admin' may choose a lower maximum Duration for any License. After the expiration, the checked-out License will return to the system automatically. However, the user may return the checked-out License earlier by selecting the Release Seat button.

Figure 3.52 Help > About Sample Dialog Box

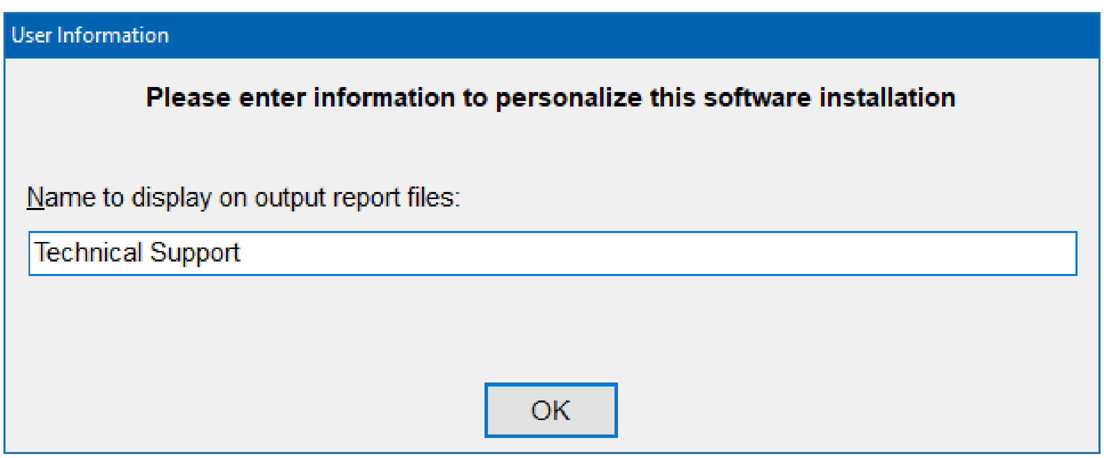
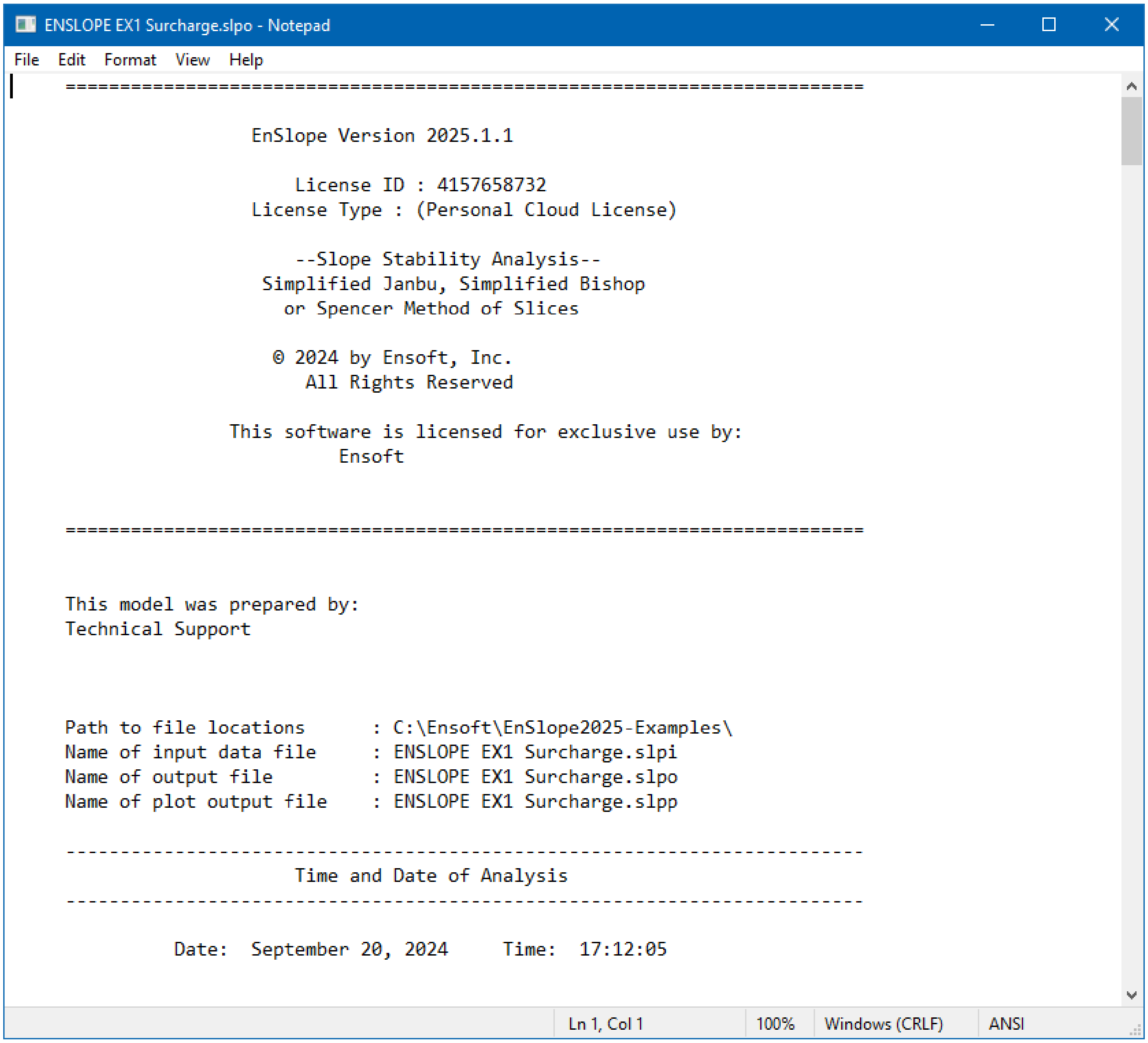


Figure 3.53 Sample Dialog Box for User Information



ENSLOPE EX1 Surcharge.slpo - Notepad

File Edit Format View Help

```
     ========================================================================

                      EnSlope Version 2025.1.1

                          License ID : 4157658732
                      License Type : (Personal Cloud License)

                          --Slope Stability Analysis--
                       Simplified Janbu, Simplified Bishop
                         or Spencer Method of Slices

                        © 2024 by Ensoft, Inc.
                           All Rights Reserved

                    This software is licensed for exclusive use by:
                              Ensoft


     ========================================================================


     This model was prepared by:
     Technical Support



     Path to file locations       : C:\Ensoft\EnSlope2025-Examples\
     Name of input data file      : ENSLOPE EX1 Surcharge.slpi
     Name of output file          : ENSLOPE EX1 Surcharge.slpo
     Name of plot output file     : ENSLOPE EX1 Surcharge.slpp

     ------------------------------------------------------------------------
                          Time and Date of Analysis
     ------------------------------------------------------------------------

               Date:  September 20, 2024     Time:  17:12:05
```

Ln 1, Col 1 | 100% | Windows (CRLF) | ANSI

Figure 3.54 Sample Heading from Output File

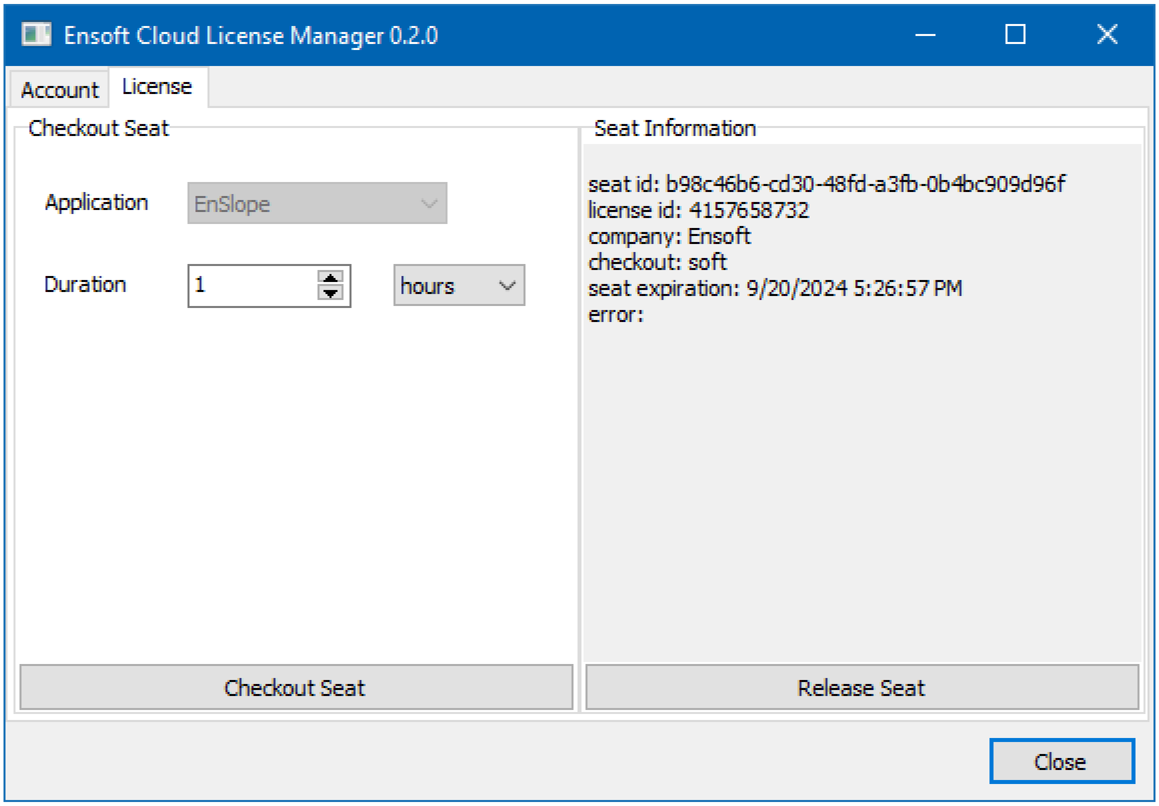


Figure 3.55 Sample Dialog Box for Ensoft Cloud License Manager

CHAPTER 4. References for Program Execution and Output Reviews

4.1 Introduction

CHAPTER 4 presents options related to the execution of the program and includes methods of addressing run-time errors. This Chapter also includes suggestions for reviewing input, output, and processor text files. The final section of this Chapter includes descriptions of all the output curves that may be observed in graphical form. The commands covered in this chapter are contained in the top menu, under the Computation and the Graphics titles.

4.2 Computation Menu

This menu option is selected to execute the program using the parameters that were saved in the input-data file. Within the options contained under this menu, shown in Figure 4.1, there are commands that facilitate the reviews of the text files produced for storing input data, output results, and processor notes. In addition, the user may select an option to observe a graphical representation of the modeled pile and soil layers. Detailed descriptions of the submenu options contained under the Computation menu are explained in the following topics.

4.2.1 Computation – Run Analysis

The input-data file will be first saved to disk after selecting the Computation – Run Analysis submenu option, which executes the analytical portion of EnSlope.

The user should remember to save the input data under a user-specified name before executing the analytical module. When saving data to disk, EnSlope will automatically add an extension of the type *.slpd* to the name of the input file.

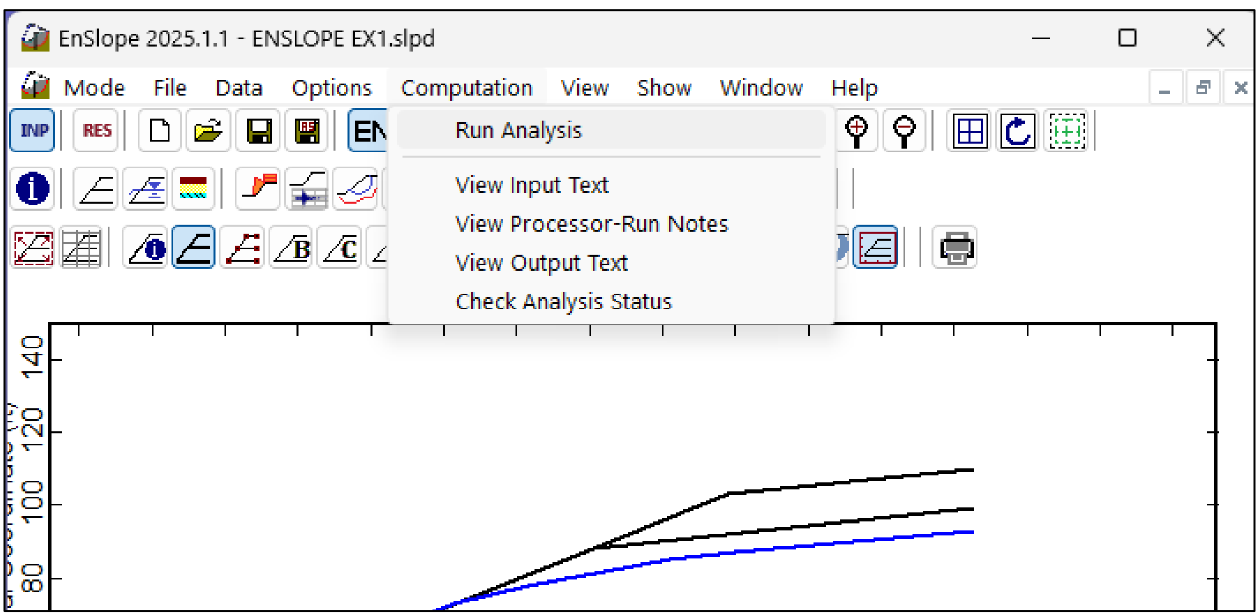


Figure 4.1 Command options contained in the Computation menu.

When the execution process is finished, the active command is returned to the main EnSlope program with a screen indicating that computations are completed. **The user should always check the output text file for any error messages that were produced during computations.**

At the beginning of the run, the analytical module will read the saved input data progressively. If an input-data format is incorrect during reading, the analytical module may stop and display an error message along with a status report in a file with the same name as the input and with the extension **.slpr*. This file may be accessed by selecting Edit Processor-Run Notes in the Computation menu. Within the processor-run notes, if all input data was read correctly, the analytical module will show the message THE EXECUTION IS IN PROGRESS.

The analytical module automatically creates an output file with the same name as the input and with the extension **.slpo*. This file may be accessed by selecting Edit Output Text in the Computation menu. Once a successful run is produced, the user may proceed to the next items for observation of results.

4.2.2 Computation – View Input Text

This submenu option is used to edit the input-data file in plain text mode. This command becomes active after new data files have been saved to disk or when opening existing data files. The command is helpful for experienced users who may want to change one or two parameters quickly using the text editor or for those users wishing to observe the prepared input data in text mode.

This submenu automatically invokes the word processor or text editor specified under Options/Control Options/Text Editor. The default setting is to use the utility program named *notepad.exe* provided by Microsoft Windows©.

Input-data files are automatically saved to disk with the user-specified file name and the extension of **.slpd* by EnSlope. The use of the notepad program for editing the input data is shown in Figure 4.2.

4.2.3 Computation - View Processor Run Notes

This submenu option is used to edit an intermediate text file that may be produced during each analytical run. This feature includes notes produced during the processing of the input data.

This submenu will automatically invoke the word processor or text editor specified under Options/Control Options/Text Editor. The default setting is to use the utility program named *notepad.exe* provided by Microsoft Windows©.

Files containing processor-run notes will be automatically saved to disk with the same file name as the input-data file but with the extension **.slpr*.

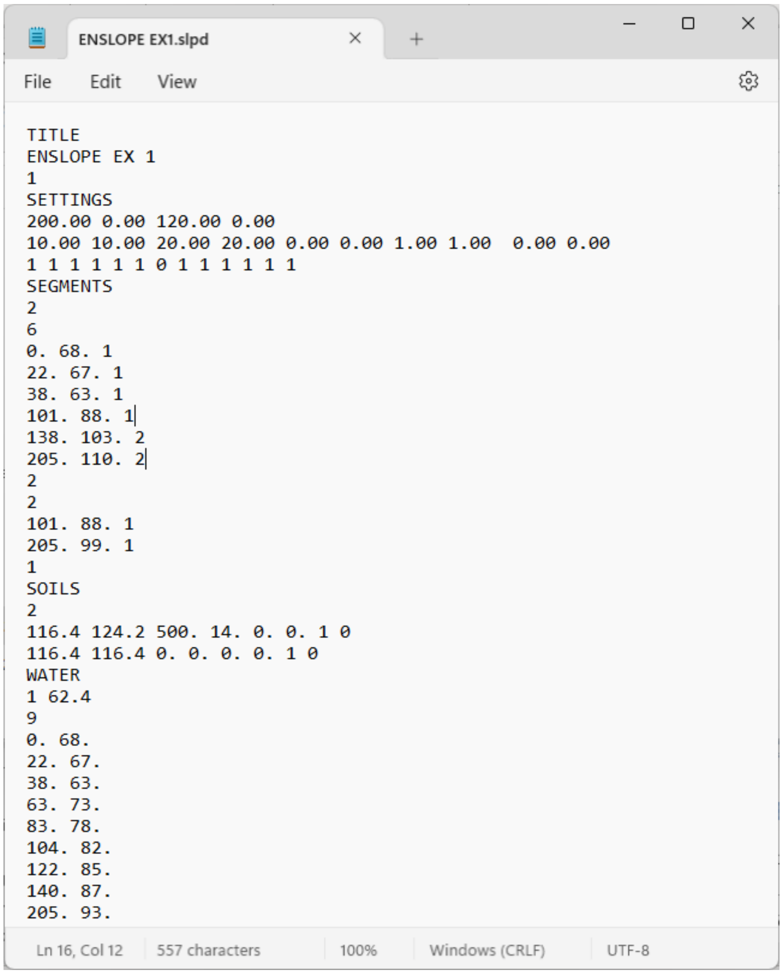


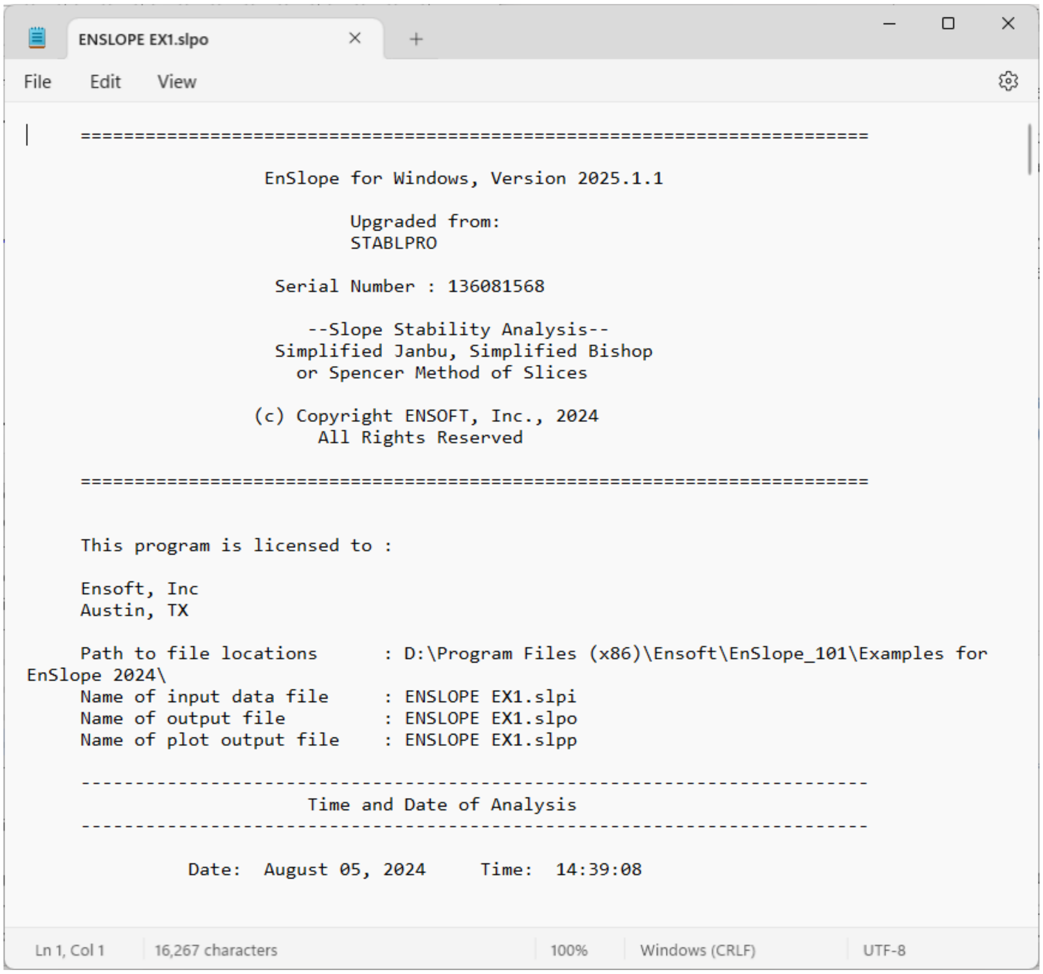
Figure 4.2 Sample use of Microsoft Notepad© for editing input text of Example Problem 1 (may change in a later version).

4.2.4 Computation – View Output Text

This submenu option is used to edit the output-text file that is automatically produced during each analytical run. This command becomes active after new data files have been saved to disk and successfully executed, or when opening previously executed data files.

This submenu will automatically invoke the word processor or text editor specified under Options/Control Options/Text Editor. The default setting is to use the utility program named *notepad.exe* provided by Microsoft Windows©.

Output files are automatically saved to disk with the same file name as the input-data file but with the extension **.slpo*. The use of Microsoft Notepad© for editing the output file for Example Problem 1 is shown in Figure 4.3.




```
     ==========================================================================

                     EnSlope for Windows, Version 2025.1.1

                             Upgraded from:
                             STABLPRO

                      Serial Number : 136081568

                         --Slope Stability Analysis--
                      Simplified Janbu, Simplified Bishop
                        or Spencer Method of Slices

                    (c) Copyright ENSOFT, Inc., 2024
                          All Rights Reserved

     ==========================================================================


     This program is licensed to :

     Ensoft, Inc
     Austin, TX

     Path to file locations      : D:\Program Files (x86)\Ensoft\EnSlope_101\Examples for
EnSlope 2024\
     Name of input data file     : ENSLOPE EX1.slpi
     Name of output file         : ENSLOPE EX1.slpo
     Name of plot output file    : ENSLOPE EX1.slpp

     --------------------------------------------------------------------------
                         Time and Date of Analysis
     --------------------------------------------------------------------------

               Date:  August 05, 2024     Time:  14:39:08
```

Figure 4.3 Sample use of Microsoft Notepad © for editing the output-text file of Example Problem 1 (may change with time).

4.3 Show Menu

The Show menu is used to observe graphics of input data and output data provided by a successful program run. Options for the observation of slope geometry, soil layers, and the critical failure surface. Options of graphics features (Figure 4.4) are briefly described below.

Most of the graphical representation for the input data and/or output data may be shown on the screen for verification by checking one or more of the following options.

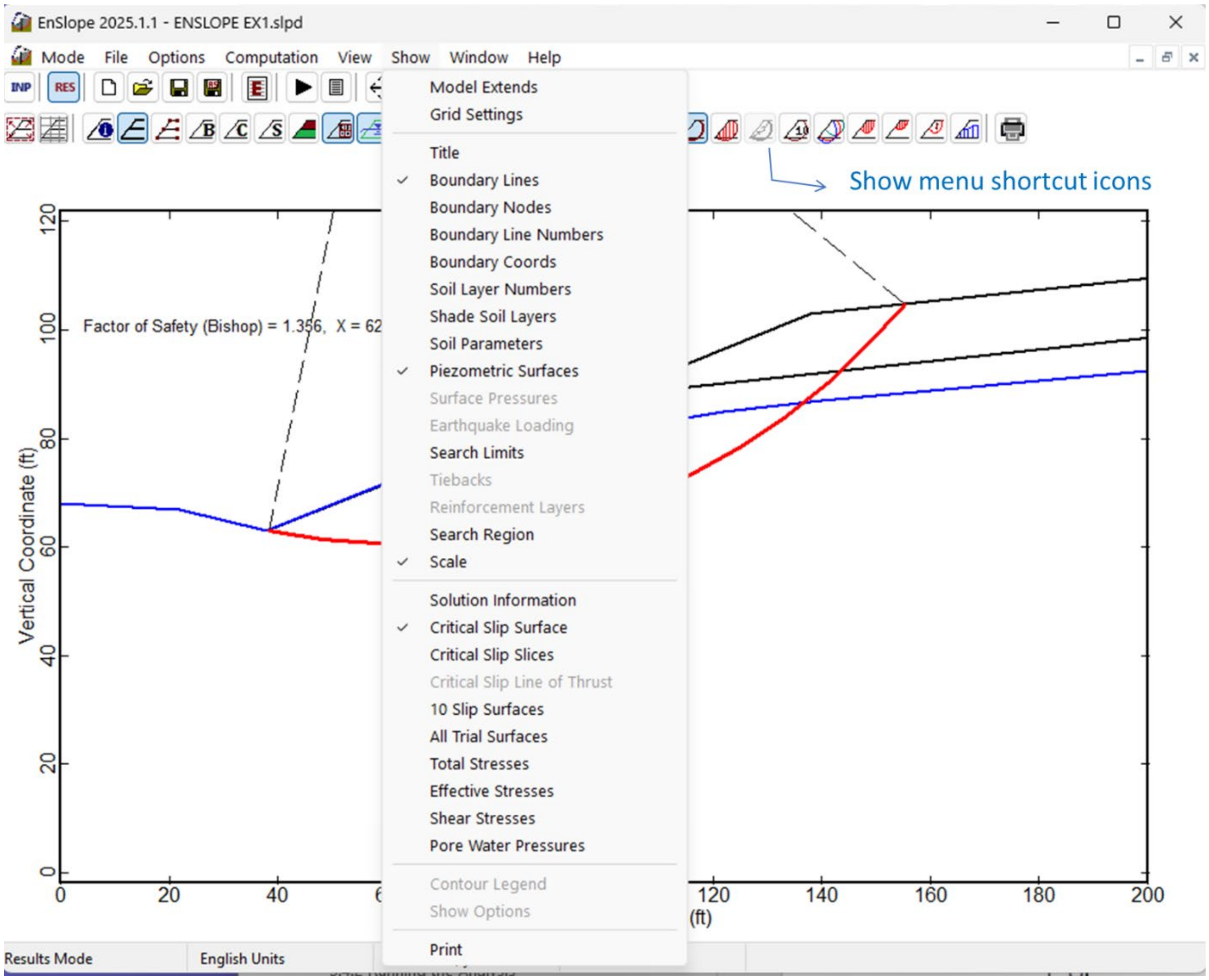


Figure 4.4 Graphics screen and options buttons.

Boundary Lines

The user may select this option to observe a graphical representation of boundary lines for the slope geometry and soil layers as shown in Figure 4.5.

Boundary Nodes

The user may select this option to observe a graphical representation of boundary nodes for the slope geometry as shown in Figure 4.5.

Boundary Line Numbers

The user may select this option to observe a graphical representation of boundary line numbers for the slope geometry as shown in Figure 4.5.

Boundary Coords

The user may select this option to observe the boundary coordinates on the graphical representation for the slope geometry and soil layers as shown in Figure 4.6.

Soil Layer Numbers

The user may select this option to observe the soil layer numbers on the graphical representation for the slope geometry and soil layers as shown in Figure 4.5.

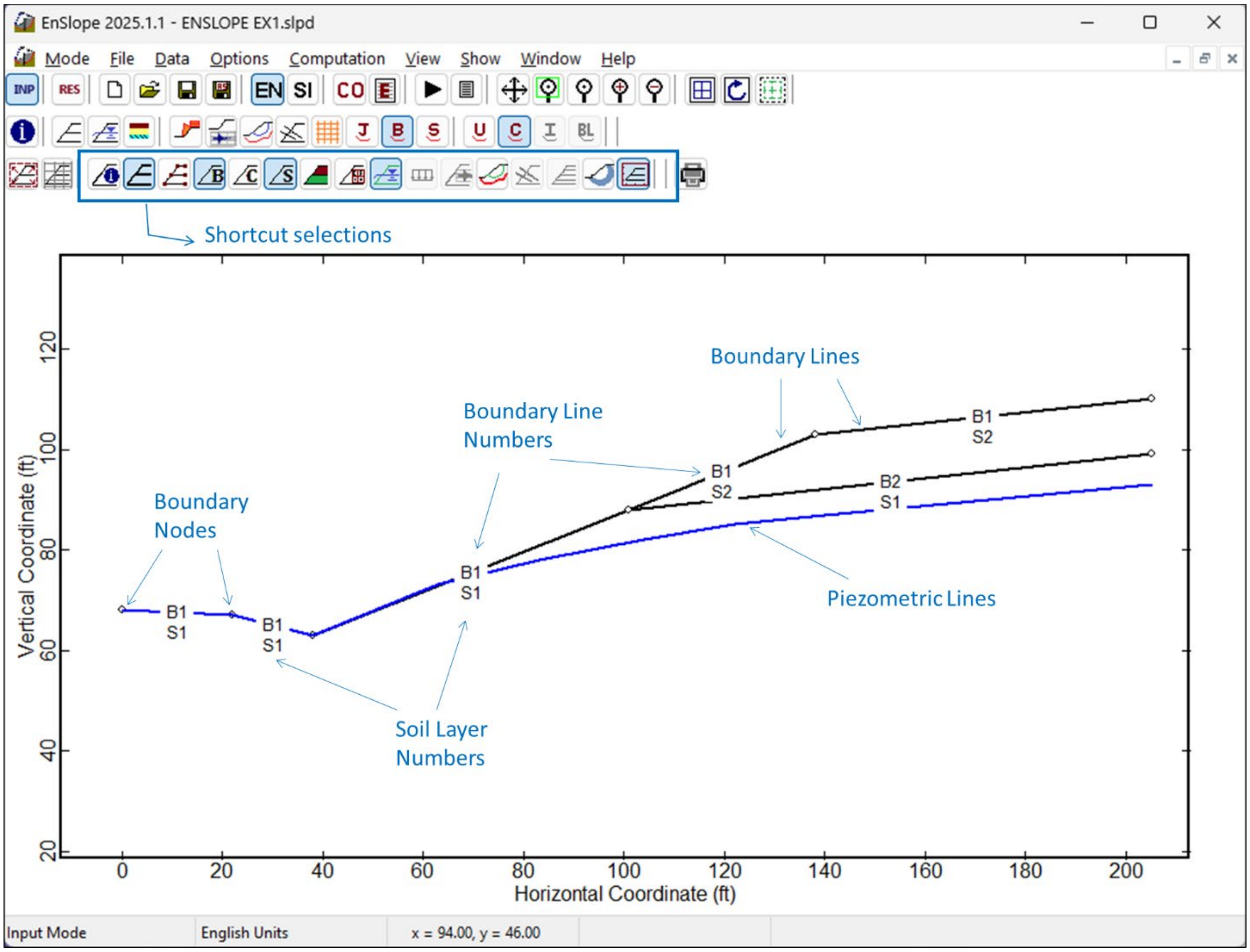


Figure 4.5 Graphics presentation for Boundary Line, Boundary Node, Boundary Line Number, Soil Layer Number, and Piezometric Line.

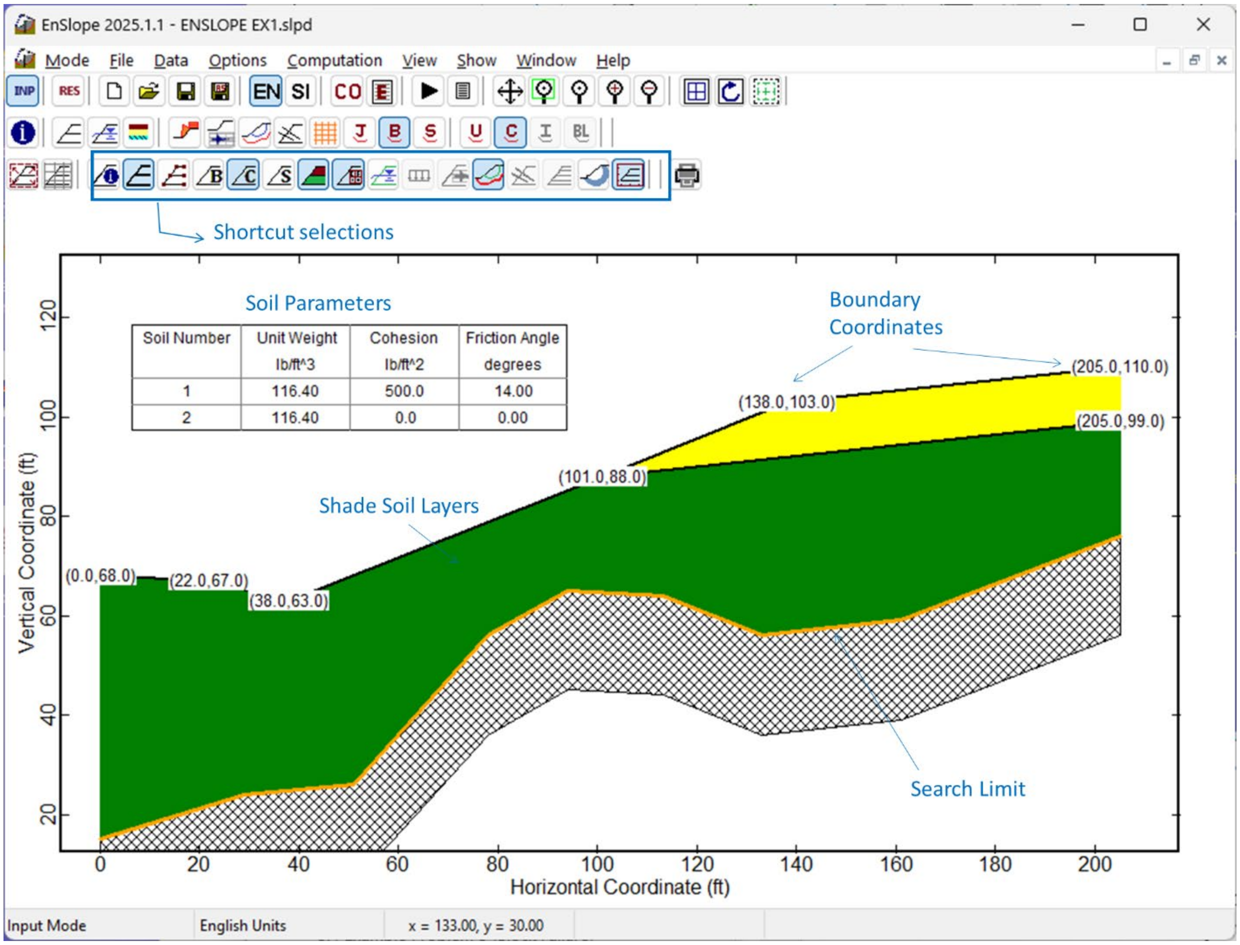


Figure 4.6 Graphics presentation for Boundary Coordinate, Soil Layer in Color, Soil Parameter, and Search Limit.

Shade Soil Layers

The user may select this option to color the soil layers on the graphical representation. It will provide a better result if the soil layers do not cross over each other as shown in Figure 4.6.

Soil Parameters

The user may select this option to check the soil parameters of each soil layer as shown in Figure 4.6.

Piezometric Lines

The user may select this option to observe a graphical representation of piezometric surfaces within the slope geometry and soil layers as shown in Figure 4.5.

Search Limits

The user may select this option to observe the search limits if defined as shown in Figure 4.6.

Tiebacks

The user may select this option to observe a graphical representation of tieback lines within the slope geometry and soil layers as shown in Figure 4.7.

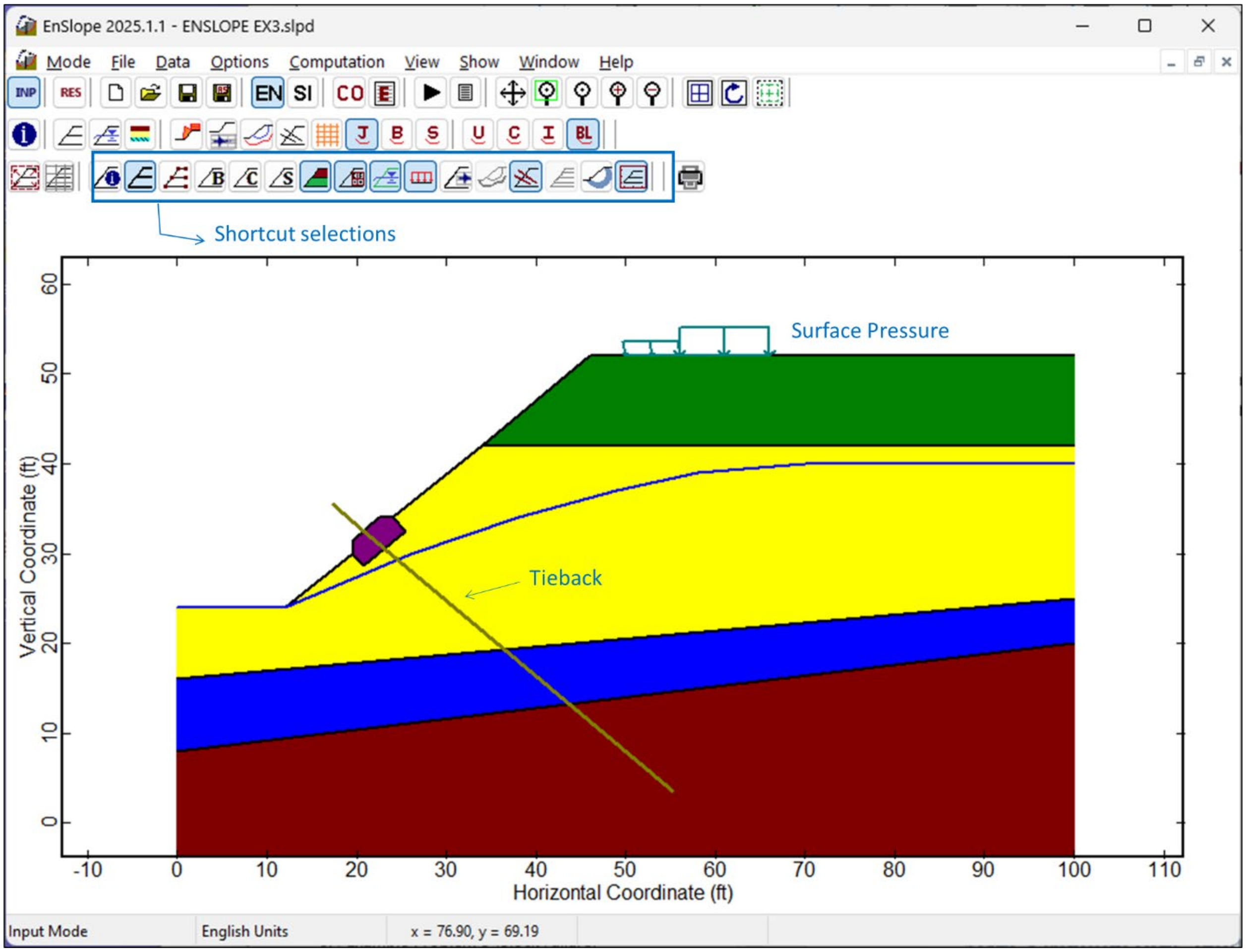


Figure 4.7 Graphics presentation for Tieback, Piezometric Line, and Surface Pressure (Surcharge Load).

Surface Pressures

The user may select this checkbox option to observe a graphical representation of surface pressure on the slope boundary. The surface pressure includes the surcharge loads applied on the surface as shown in Figure 4.7.

Reinforcement Lines

The user may select this check-box option to observe a graphical representation of reinforcement layers within the slope geometry and soil layers as shown in Figure 4.8.

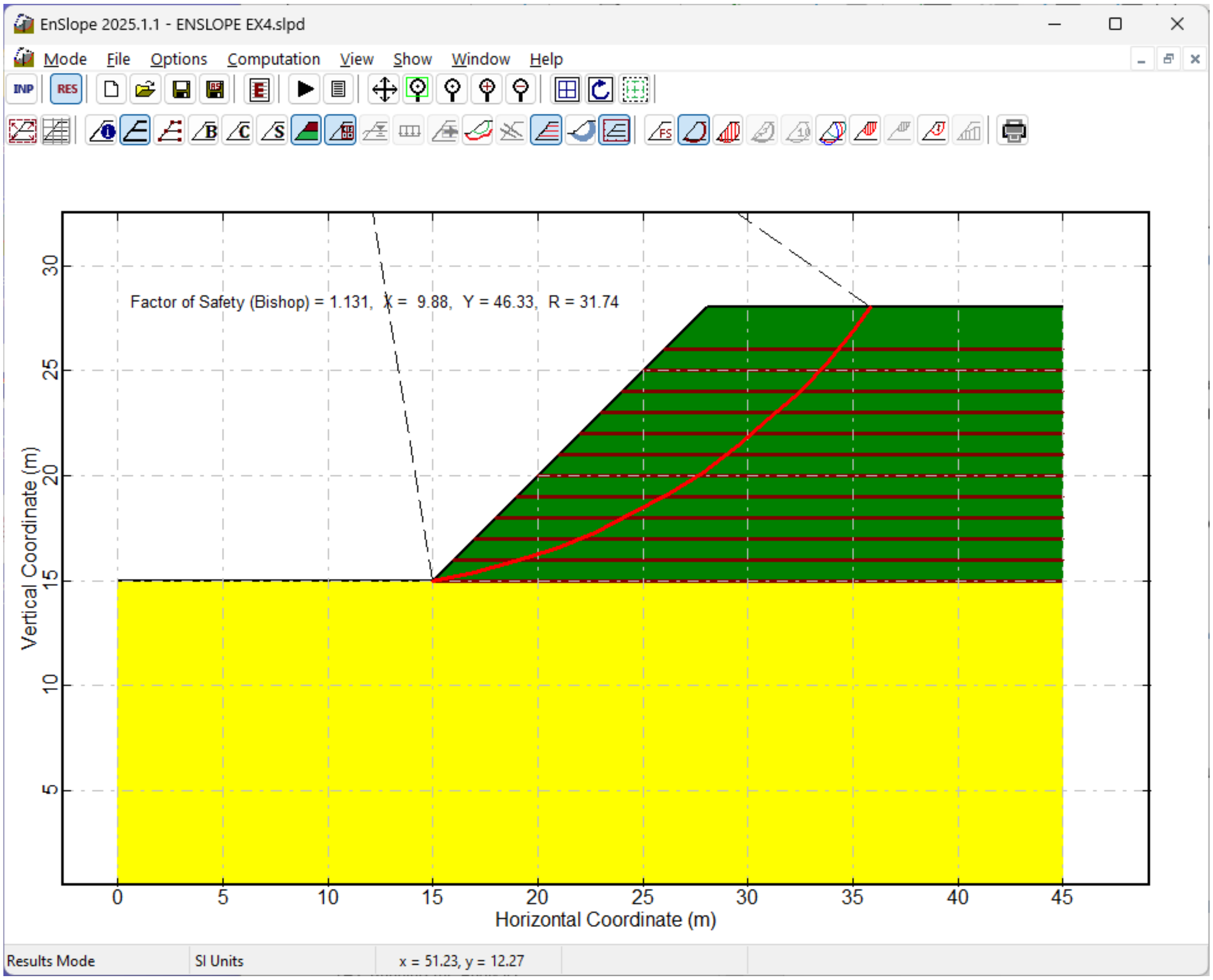


Figure 4.8 Graphics presentation for Reinforced Earth Layers

Solution Information

The user may select this check-box option to observe the solution information of the most critical failure surface.

The Most Critical Slip Surface

The user may select this check-box option to observe the most critical slip surface within the slope boundaries as shown in Figure 4.9.

10 Critical Slip Surfaces

The user may select this option to observe the 10 most critical slip surfaces within the slope boundaries as shown in Figure 4.9.

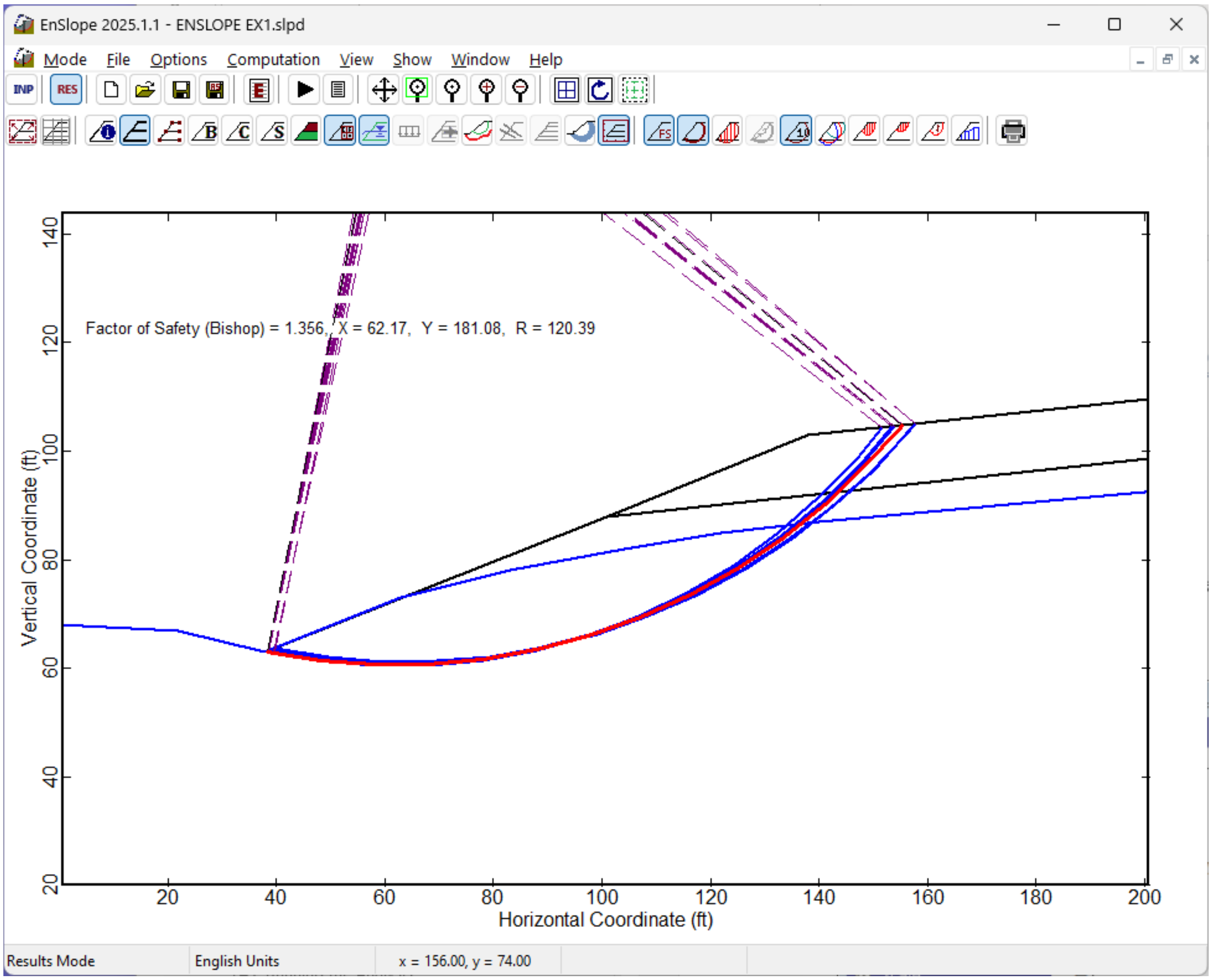


Figure 4.9 Graphics presentation for the most critical slip surface and the 10 critical slip surfaces

All Trial Slip Surfaces

The user may select this check-box option to observe all the slip surfaces within the slope boundaries as shown in Figure 4.10. Double-clicking in the area of the legend will open a dialog box, that will allow the change of the limits and increments of the safety factors plotted in the figure. It should be noted that the "Hide curves outside limits" option is not checked, so all surfaces with a safety factor greater or equal to 1.4 are plotted in purple.

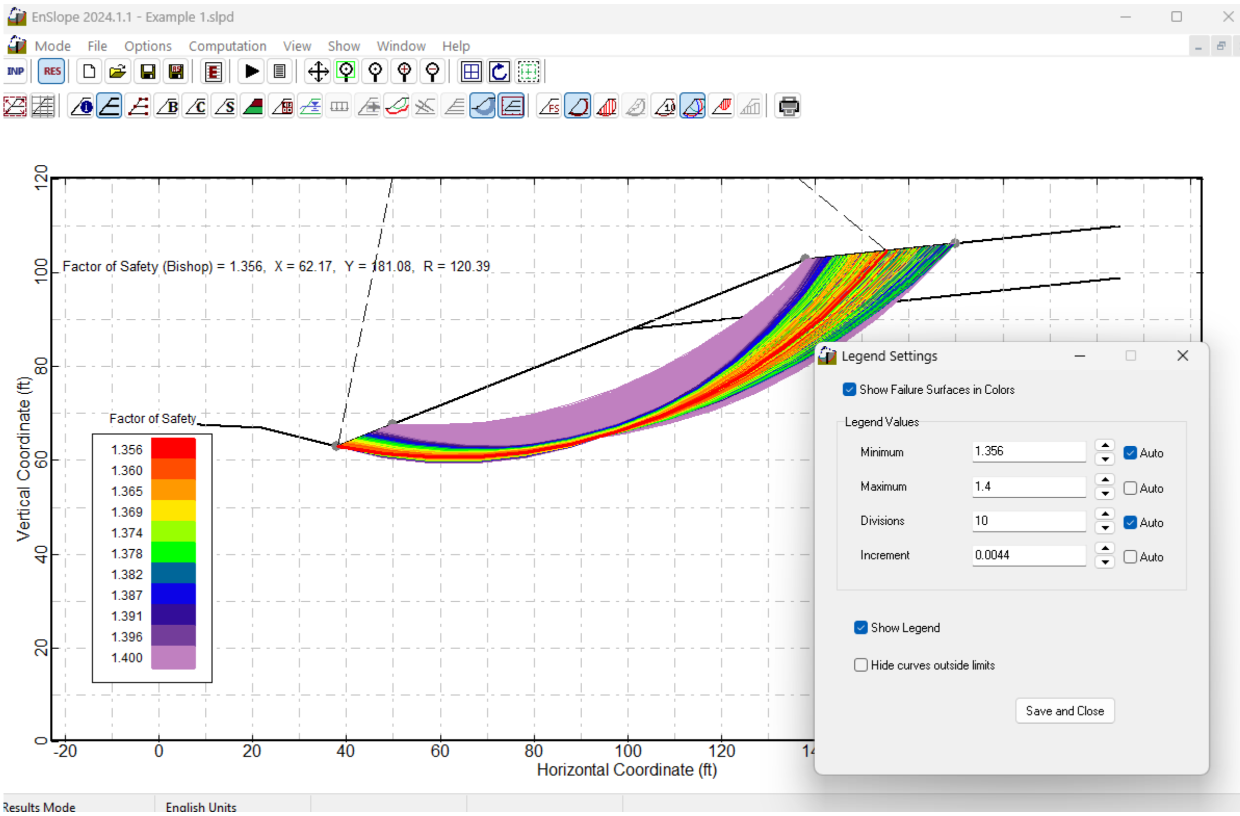


Figure 4.10 Graphics presentation for all trial slip surfaces

Total Stresses

The user may select this check-box option to observe the distribution of total weight at the bottom of each slice for the most critical slip surface as shown in Figure 4.11.

Pore Water Pressures

The user may select this checkbox option to observe the distribution of pore water pressure at the bottom of each slice for the most critical slip surface.

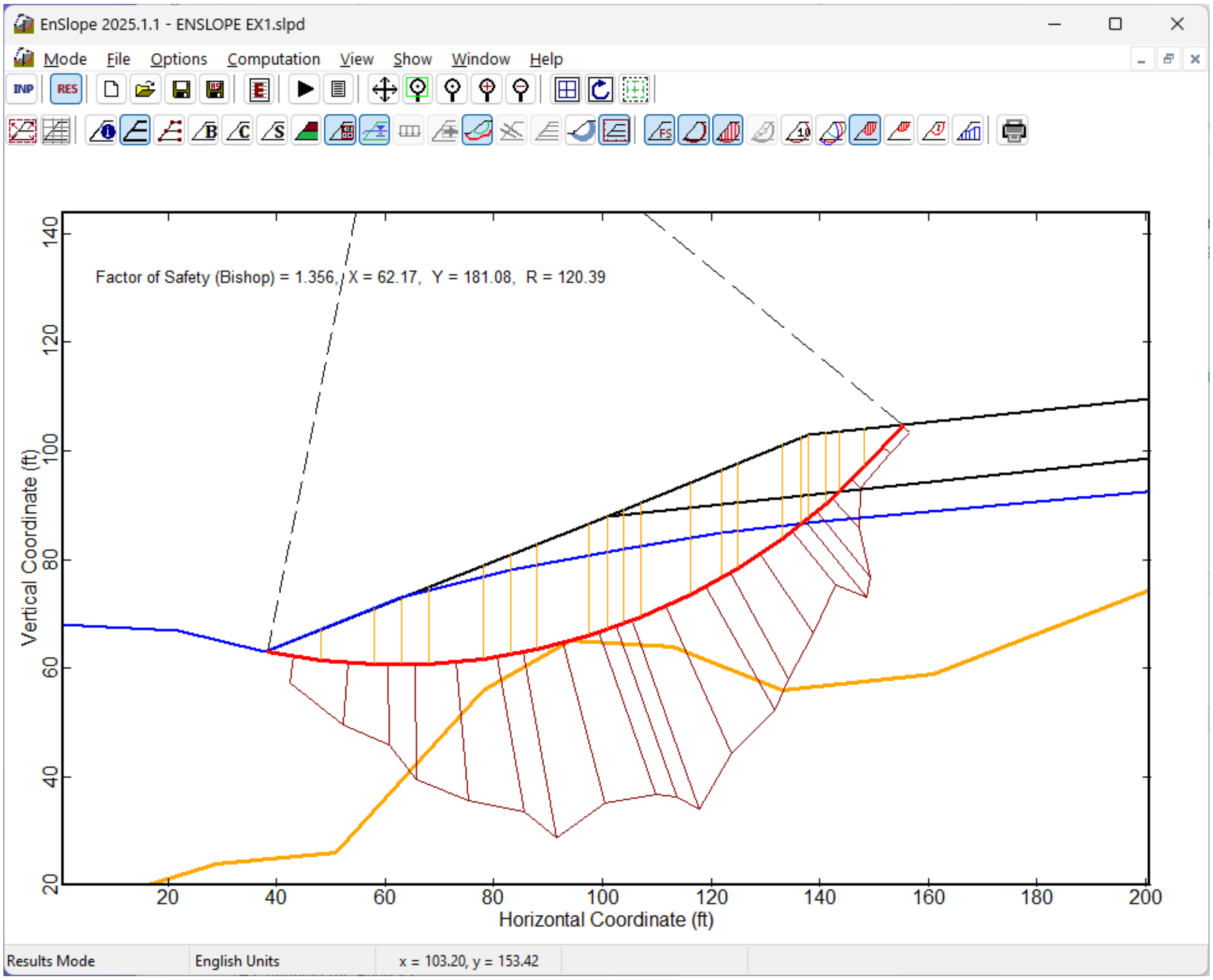


Figure 4.11 Graphics presentation for the total vertical stresses

CHAPTER 5. Example Problems

5.1 Introduction

This chapter presents several examples that were solved using EnSlope. To ensure accuracy from the computer results, some examples have been compared with the results from hand calculations. The step-by-step hand calculations were carried out based on the procedures described in the accompanying EnSlope Technical Manual. The users can have confidence in their results if limited amounts of hand calculations can be done for comparisons.

There are three types of output data provided by the computer. The first type is the output file which contains formatted text that consists of an echo-print of the input data; the distribution of skin friction, end bearing, and total capacity; and the final load-settlement curve. The second type of output presents the data for a graphics file that allows the code to produce plots. All the data are saved in ASCII format and the user may access the files with any text editor.

Several problems are provided herein as examples of different applications that may be solved using our computer program EnSlope. Each example focuses on a particular computational feature of the program. Input files for each example are automatically copied to the EnSlope data directory during installation (*<Root Drive>\Ensoft\EnSlope2025-Examples*).

Example problems provide the user with information on the input and output of various cases and present a quick tutorial for real-world applications. The user is encouraged to study these examples and, with modifications, may even use them to solve similar problems. However, by no means can these limited examples explore the full functions and features provided by EnSlope.

It should be noted that each example is designed for certain tutorial purpose. The resulting safety factor may not represent the minimum safety factor of each slope.

The main features of each example included with EnSlope are summarized as follows.

Example Problem 1

- long term stability of a cut in a soft clay material

Example Problem 2

- excavation in a silty sand layer with vertical sides supported by steel sheet piling,

Example Problem 3

- use of tiebacks for stabilizing an unstable earth slope

Example Problem 4

- analysis of an embankment constructed on soft ground reinforced with 12 layers of reinforcement

Example Problem 5

- use of tiebacks for stabilizing an unstable earth slope

Example Problem 6

- application with complicated soil conditions
- example with S.I. units.

Example Problem 7

- application with piles in the slope

5.2 Example Problem 1 (English Units)

The example concerns the long-term stability of a cut in a soft clay material (Figure 5.1). A ground water table is presented at a depth of about 17 ft below the existing ground surface which gently slopes toward the cut. An irregular bedrock surface lies at a relatively shallow depth. The variation of the bedrock surface normal to the plane of the profile is insignificant. Therefore, a two-dimensional analysis is assumed appropriate.

The shear parameters (c' = 500 psf, ϕ = 14 deg.) do not vary significantly with depth, but due to desiccation, tension cracks are assumed to extend to a depth of approximately 11 feet. By defining the problem geometry with straight lines, a total of six boundary lines are used for this example. The boundaries are ordered ground surface boundaries first, left to right, with the single subsurface boundary last, satisfying program requirements. The 4th and 5th boundaries on the ground surface are above the tension crack zone, so they are assigned a different soil type number from that assigned to the other boundaries. The clay below the tension zone has been arbitrarily assigned soil type number 1, which has the original shear parameters (c' = 500 psf, ϕ = 14 deg.). The clay within the tension zone is soil type number 2, which has zero shear parameters (c' = 0 psf, ϕ = 0 deg.) in the analysis.

The bedrock has been assumed competent, with no possibility of failure within it. Therefore, limits for surface generation boundaries are used to approximate the bedrock surface. The generation of trial failure surfaces that pass through the bedrock is thus prevented.

The Simplified Bishop method is used for the slope-stability analysis. Searching for the critical surface is carried out with 5000 trial failure surfaces generated by the program. The resulting factor of safety is 1.356. It should be noted that this zero-shear-strength approach assumes that the tension crack occurs along the circular failure surface. An alternative approach is to replace the tension portion of the soil with a surcharge of equivalent weight. This alternative approach assumes the tension cracks are vertical, and yields a higher factor of safety (1.483) as less soil mass is included in the sliding mass.

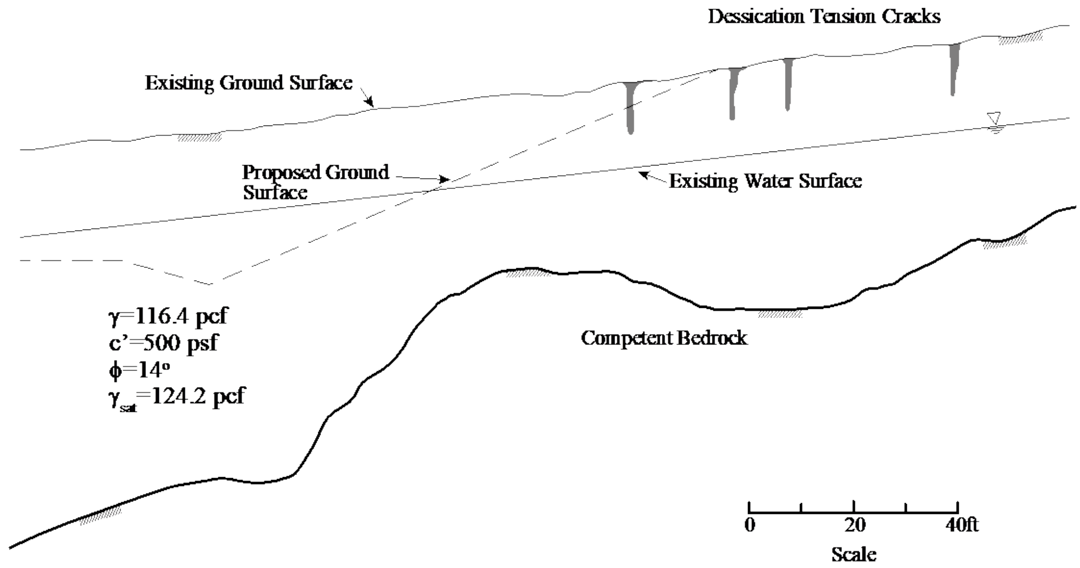


Figure 5.1 General soil description of Example Problem 1.

5.2.1 Input Data for Computer Analysis

Users can use the *Data* menu or the quick-access icons (in the 2nd row) to input data for analysis. It should be noted that data input can only be accessed in the *Input* mode. Users can select input mode from the *Mode* menu or click on the INP icon in the first row of the quick access icons. The steps below show data input using the *Data* menu.

Step 1: Enter project title: Click on the *Data* menu and select *Title*. Input information about the analyses, then click on "Save and Close". This field is limited to 1 line.

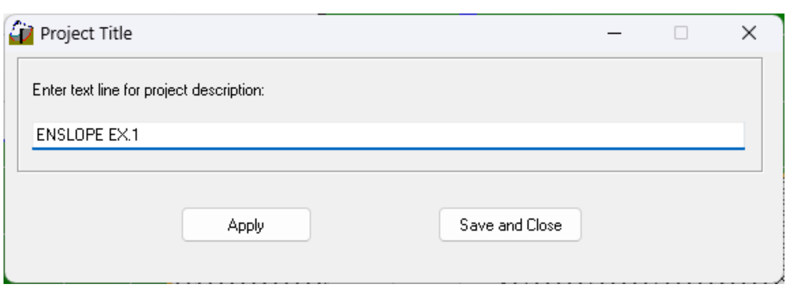


Figure 5.2 Input Project title for Example Problem 1.

Step 2: Enter slope segments: Click on the *Data* menu and select *Boundary Segments*. A pop-up window named "Boundary Segments" will appear (Figure 5.3). Users can choose to input the segment point-by-point or input the coordinates with a table. It is recommended to input the coordinates with a table by clicking on the "Nodes Table" to open the Node Coord window. Users can type in the coordinates and soil numbers shown below in the table. Alternatively, the data can be copied and pasted (click on "paste values from clipboard") into the table. The 3 numbers in each row represent the x, and y coordinates, and the material number.

0. 68. 1

22. 67. 1

38. 63. 1

101. 88. 1

138. 103. 2

205. 110. 2

There are 2 segments (soil layer lines) in this example. It should be noted that **the first segment must contain the entire surface of the slope.** Close the "Nodes Table" window. Click on "End Segment" to end the segment. Click on "Add Segments" to add the second layer line. Click on "Nodes Table", and copy the data below into the table.

101. 88. 1

205. 99. 1

Close the "Nodes Table" and the "Boundary Segments" windows. Click on "End Segment" to end the segment. Two segment lines should be displayed on the main window.

Step 3: Enter piezometric surfaces: Click on the *Data* menu and select *Piezometric Surfaces*. A pop-up named "Piezometric Surfaces" will appear (Figure 5.4). Click on "Nodes Table", and copy the data below into the table.

0. 68.

22. 67.

38. 63.

63. 73.

83. 78.

104. 82.

122. 85.

140. 87.

205. 93.

Close the "Nodes Table" and the "Piezometric Surfaces" windows. A blue line representing the piezometric surfaces is added in the main window.

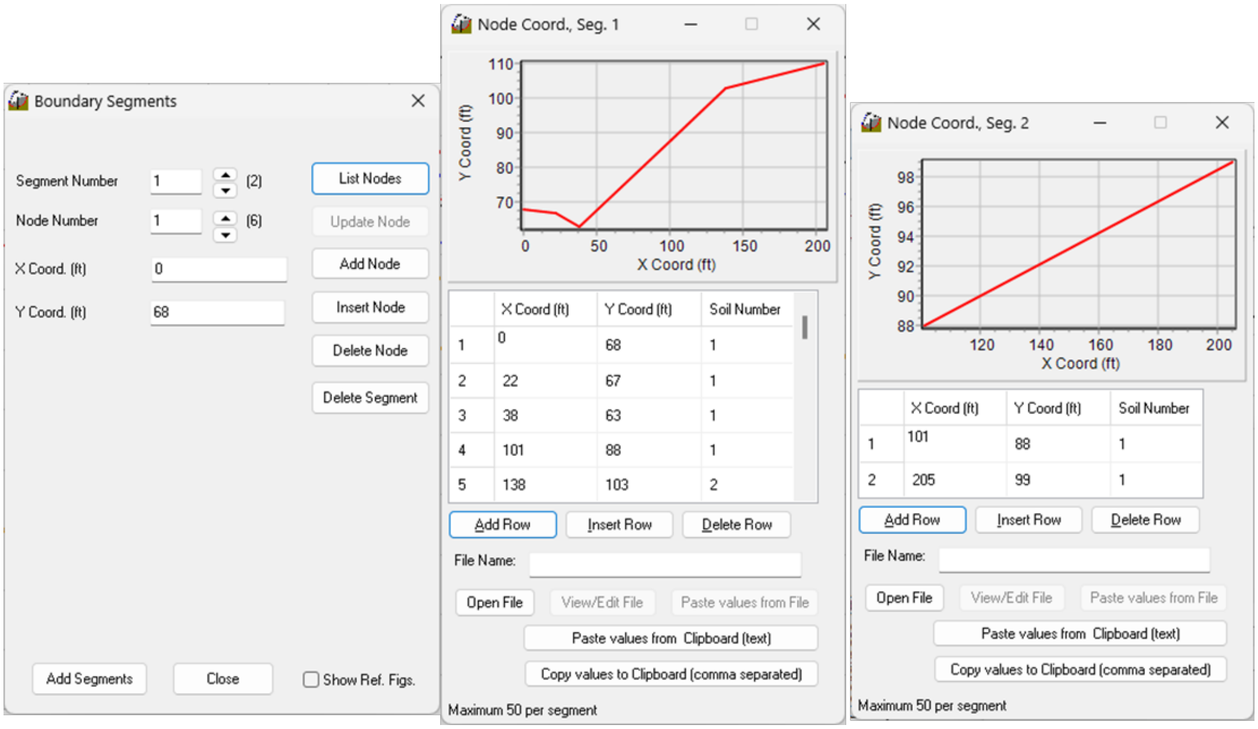


Figure 5.3 Input Boundary Segments for Example Problem 1.

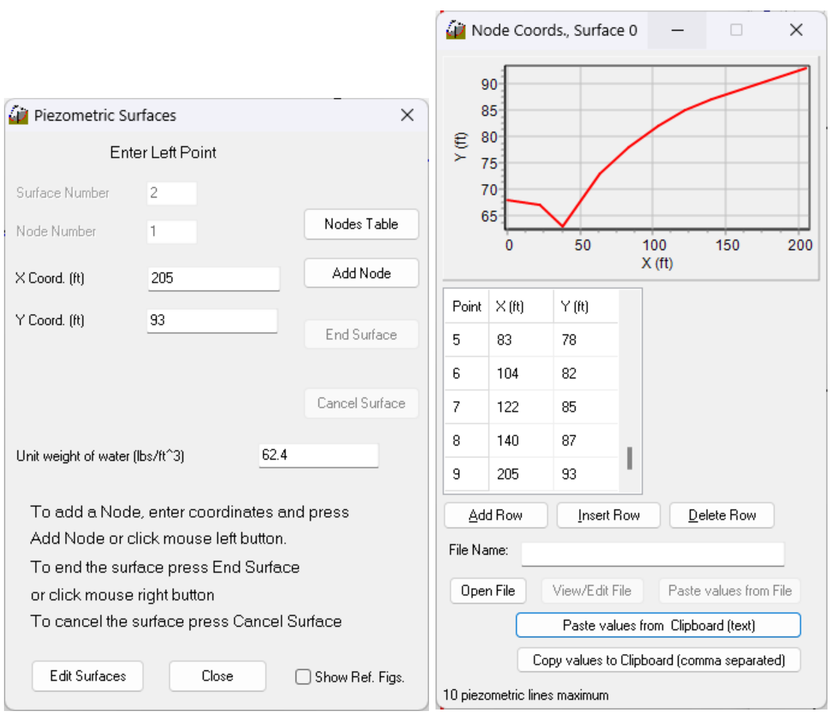


Figure 5.4 Input Piezometric Surfaces for Example Problem 1.

Step 4: Enter soil properties: Click on the *Data* menu and select *Soil Properties*. A pop-up named “Soil Properties” will appear (Figure 5.5). Input data as shown in the figure below for Soil #1 and Soil #2. Click on “Close” to close the window.

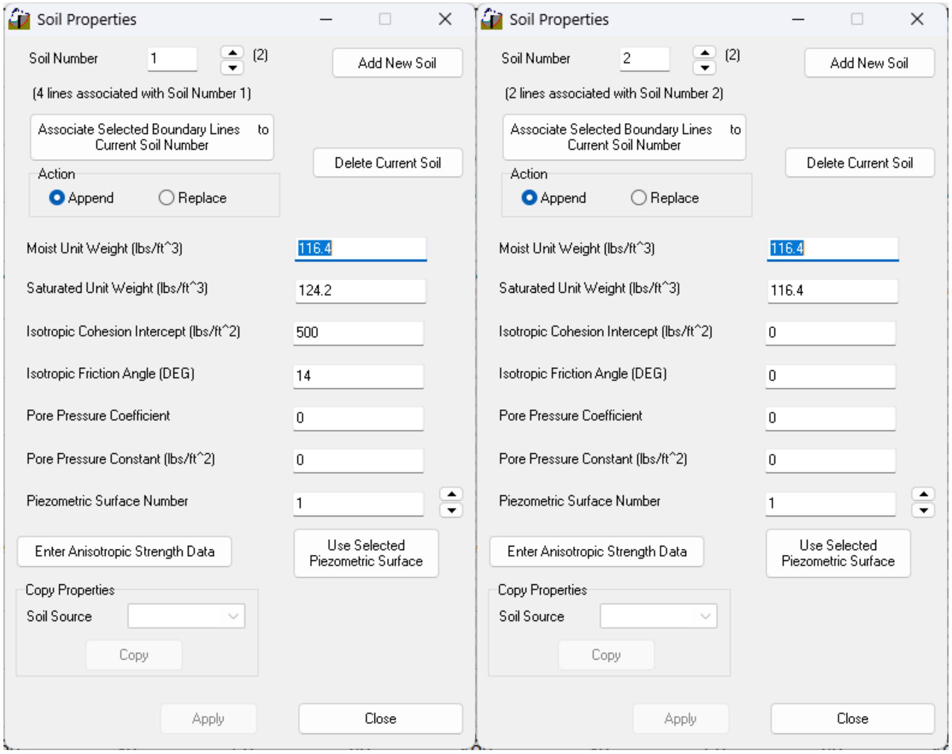


Figure 5.5 Input Soil Properties for Example Problem 1.

Step 5: Enter trial surface limits: Click on the *Data* menu and select *Trial Surface Limits*. A pop-up named “Trial Surface Limits” will appear (Figure 5.6). Click on “Nodes Table”, and copy the data below into the table.

0. 15.

29. 24.

51. 26.

78. 56.

94. 65.

113. 64.

133. 56.

161. 59.

205. 76.

Close the “Nodes Table” and the “Trial Surface Limits” windows. The trial surface limit will show in the main window.

Step 6: Select the method of analysis: Click on the *Data* menu and select *Method of Analysis*. Select “*Bishop’s Method*”

Step 7: Select the failure surface search: Click on the *Data* menu and select “*Failure Surface Search*”. Select “Generate Circular Failure Surface Search”, and a window named “*Circular Failure Surface Search*” will appear (Figure 5.7). Enter data as shown in the figure below for failure surface search. Click on "Close" to close the window.

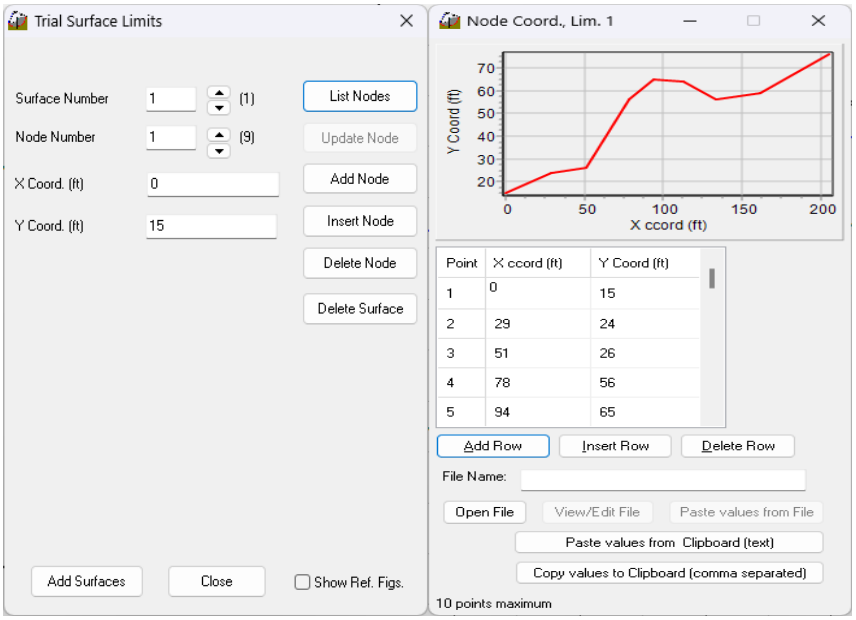


Figure 5.6 Input Trial Surface Limits for Example Problem 1.

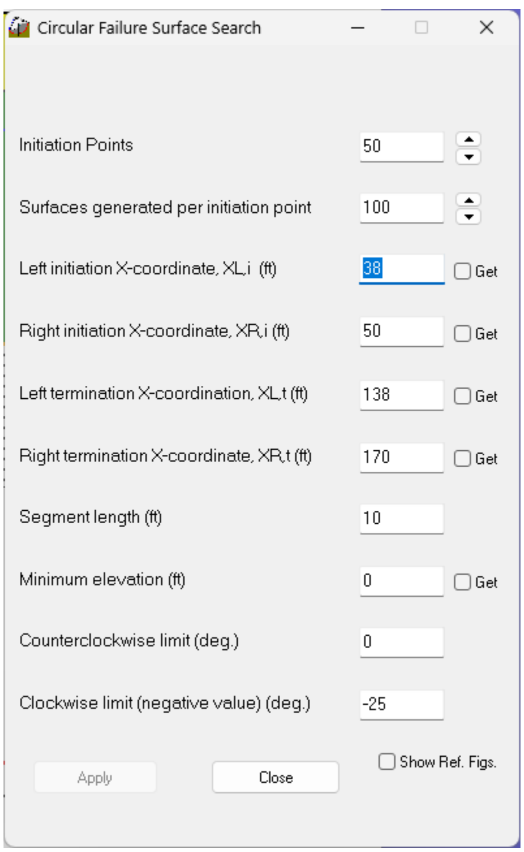


Figure 5.7 Circular Failure Surface Search Parameters for Example Problem 1.

5.2.2 Running the Analysis

Users can use the "*Run Analysis*" tab in the "*Computation"* menu or the ▶ icons to run the analysis. The program will switch to "Result" mode and the critical surface will be shown on the main window.

5.2.3 Output Data

Users can review the output data from the "*View output text*" tab in the "*Computation"* menu or the icons.

5.2.4 Graphical Results of Computer Analysis

The critical failure surface is marked in red, and the factor of safety is 1.356. It is useful to plot all trial surfaces together for comparison as shown in Figure 5.8. Double-clicking in the area of the legend will open a dialog box, that will allow the change of the limits and increments of the safety factors plotted in the figure (Figure 5.9). It should be noted that the "Hide curves outside limits" option is not checked, so all surfaces with a safety factor greater or equal to 1.4 are plotted in purple.

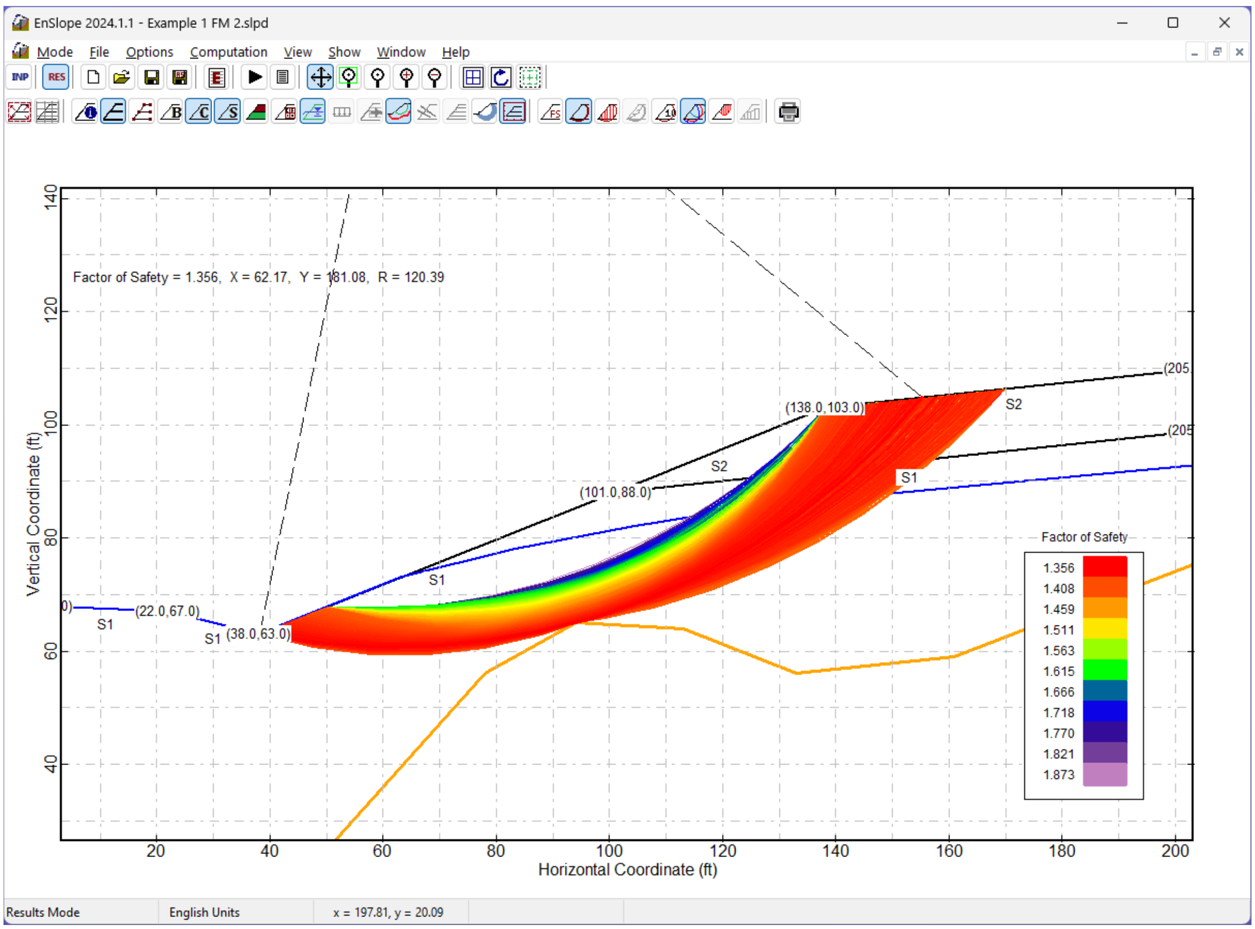


Figure 5.8 Plot of the most critical failure surface and all trial surfaces of Example Problem 1.

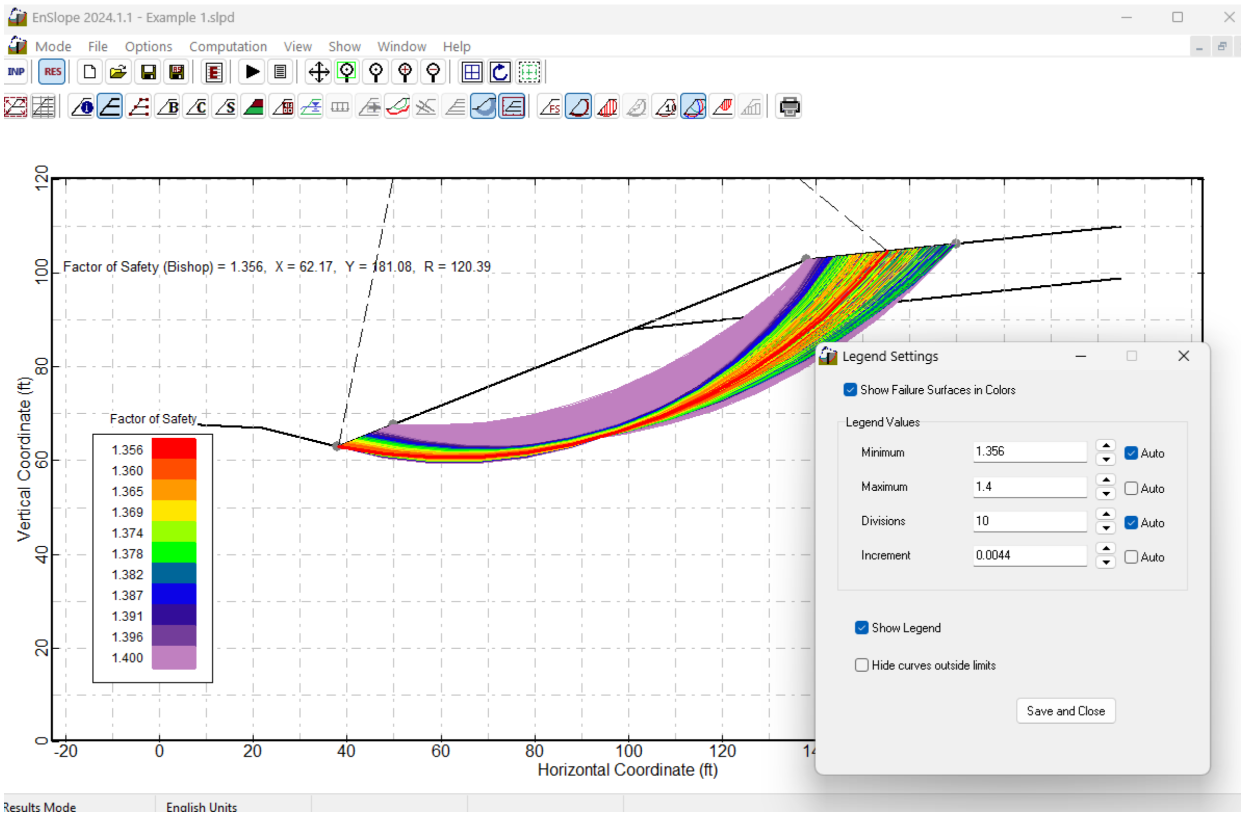


Figure 5.9 Plot of the most critical failure surface and all trial surfaces of Example Problem 1 with the range of safety factor between 1.356 and 1.4.

5.3 Example Problem 2 (SI Units)

The profile shown in Figure 5.10 represents a proposed excavation in a silty sand layer with vertical sides supported by steel sheet piling. It has been determined that the critical failure surface is circular and exits the slope at the toe of the sheeting. The minimum factor of safety for overall stability was 0.71 without using any tiebacks.

Two rows of tiebacks are required for local stability of the wall. The first (top) row of tiebacks will be horizontal, and the free length of the tiebacks will be 13 m. The first row of tiebacks will each carry a load of 660 kN and will be spaced 10 m apart horizontally. The second (lower) row of tiebacks will be inclined 15 degrees as measured clockwise from the horizontal and will have a free length of 10 m. Each tieback in this row will carry a load of 900 kN and will also be at a 10 m horizontal spacing. Both rows of tiebacks will transfer their loads to the sheeting using horizontal steel beams for Wales.

Therefore, the assumption of a uniform distribution of load between the tiebacks will be reasonable for this case since the action of the wale will cause an equivalent horizontal line load to be formed for each row of tiebacks. It is desired to know what effect the tiebacks have on the factor of safety of the previously mentioned critical failure surface. Therefore, the program will be run using a specified circular failure surface. The input data and output results are given in the following pages for reference.

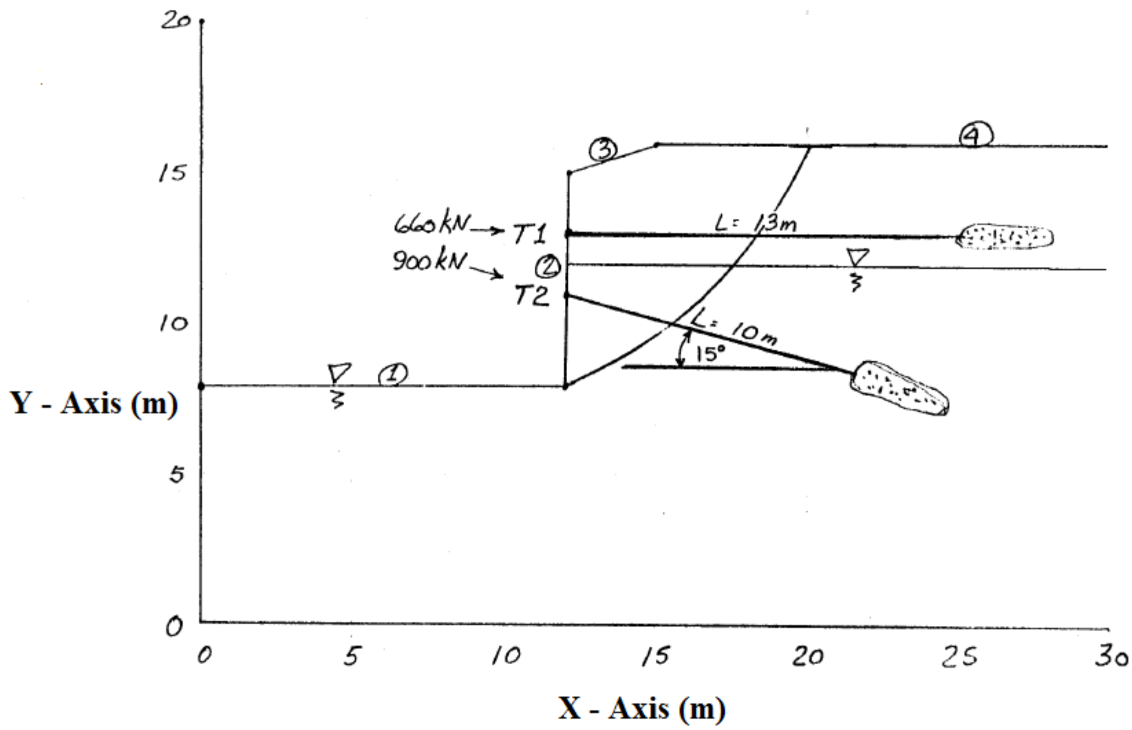


Figure 5.10 General soil description of Example Problem 2.

5.3.1 Input Data for Computer Analysis

Users can use the *Data* menu or the quick-access icons (in the 2nd row) to input data for analysis. It should be noted that data input can only be accessed in the *Input* mode. Users can select input mode from the *Mode* menu or click on the  icon in the first row of the quick access icons. The steps below show data input using the *Data* menu.

Step 1: Enter project title: Click on the *Data* menu and select *Title*. Input information about the analyses, then click on "Save and Close". This field is limited to 1 line.

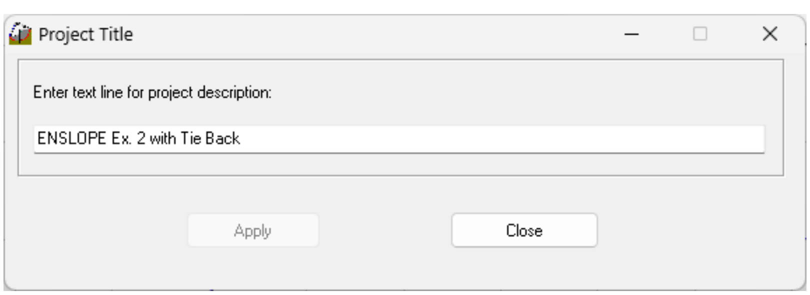


Figure 5.11 General soil description of Example Problem 2.

Step 2: Enter slope segments: Click on the *Data* menu and select *Boundary Segments*. A pop-up window named "Boundary Segments" will appear (Figure 5.12). Users can choose to input the segment point-by-point or input the coordinates with a table. It is recommended to input the coordinates with a table by clicking on the "Nodes Table" to open the Node Coord window. Users can type in the coordinates and soil numbers shown below in the table. Alternatively, the data can be copied and pasted (click on "paste values from clipboard") into the table. The 3 numbers in each row represent the x, and y coordinates, and the material number.

```
0. 8. 1
12. 8. 1
12.1 15. 1
15. 16. 1
30. 16. 1
```

There is only 1 segment (soil layer lines) in this example. It should be noted that **the first segment must contain the entire surface of the slope.** Close the "Nodes Table" window. Click on "End Segment" to end the segment.

Step 3: Enter piezometric surfaces: Click on the *Data* menu and select *Piezometric Surfaces*. A pop-up named "Piezometric Surfaces" will appear (Figure 5.13). Click on "Nodes Table", and copy the data below into the table.

```
0. 8.
12. 8.
12.05 12.
30. 12.
```

Close the "Nodes Table" and the "Piezometric Surfaces" windows. A blue line representing the piezometric surfaces is added in the main window.

Step 4: Enter soil properties: Click on the *Data* menu and select *Soil Properties*. A pop-up named "Soil Properties" will appear. Input data is shown in Figure 5.14 for Soil #1. Click on "Close" to close the window.

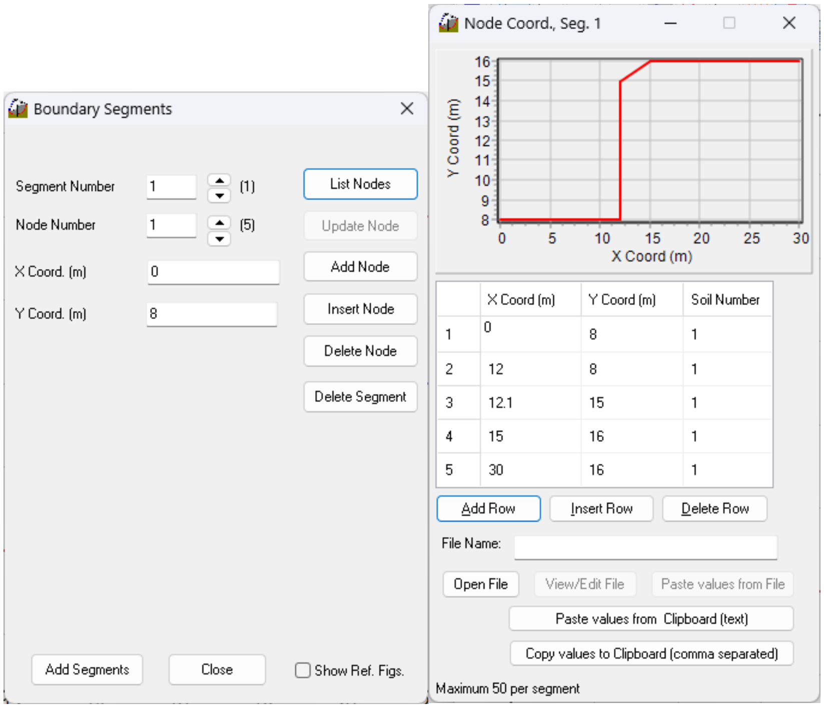


Figure 5.12 Input Boundary Segments for Example Problem 2.

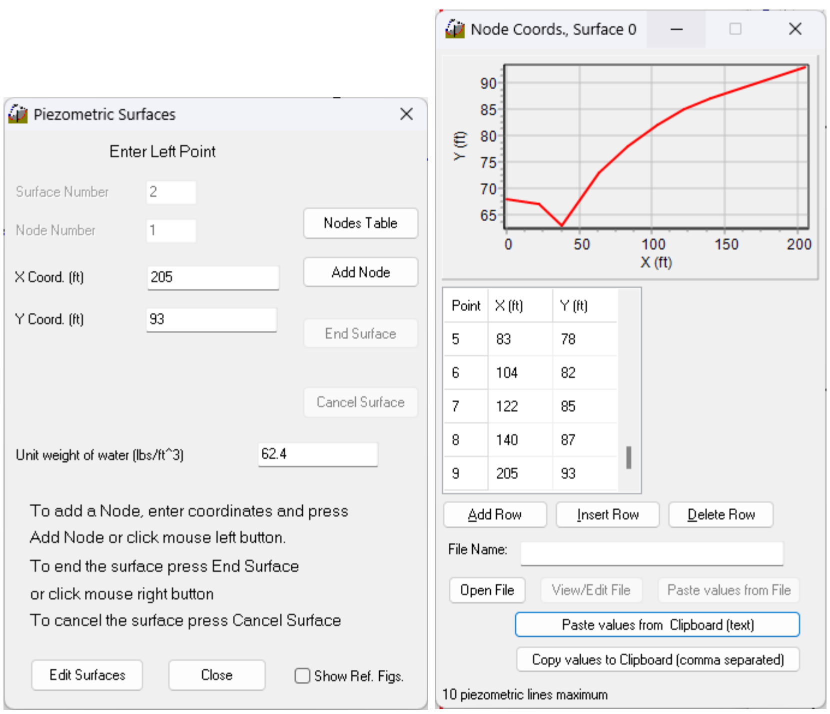


Figure 5.13 Input Piezometric Surfaces for Example Problem 2.

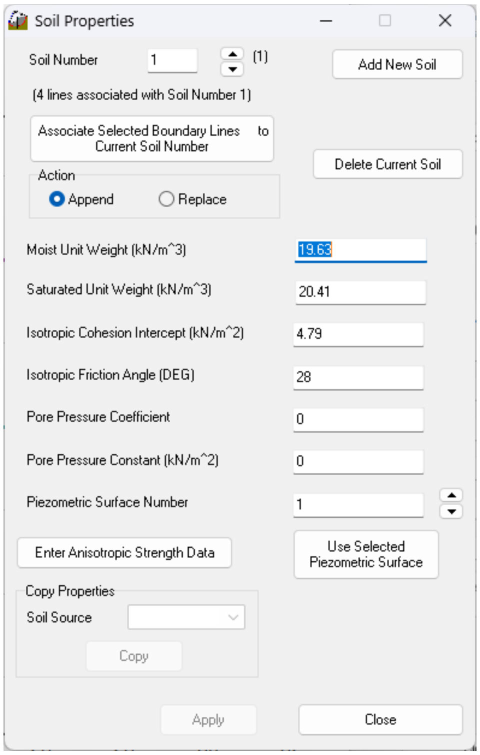


Figure 5.14 Input Soil Properties for Example Problem 2.

Step 5: Enter tiebacks information: Click on the *Data* menu and select *Tiebacks*. A pop-up named "Tiebacks" will appear. Input data as shown in Figure 5.15 to Tieback #1 and Tieback #2. Click on "Close" to close the window.

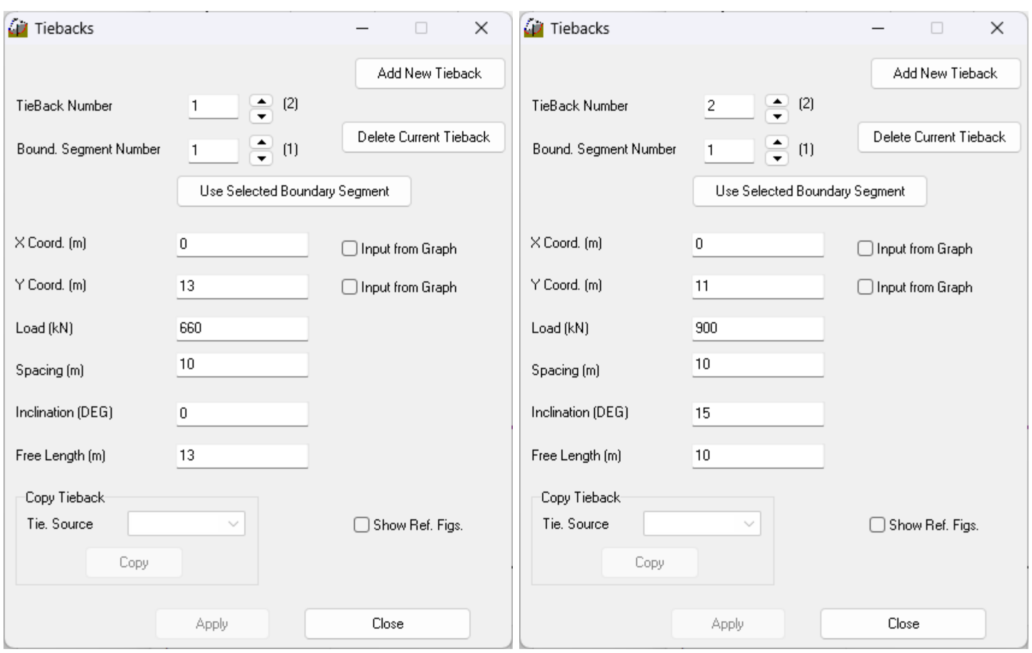


Figure 5.15 Input Tieback Properties for Example Problem 2.

Step 6: Select the method of analysis: Click on the *Data* menu and select *Method of Analysis*. Select "*Janpu's Method*."

Step 7: Select the failure surface search: Click on the *Data* menu and select "*Failure Surface Search*". Select "*User-Defined Failure Surface*", and a pop-up named "*User-Defined Failure Surface*" will appear. Click on "Nodes Table", and copy the data below into the table.

```
12. 8.
13.8 8.9
15.5 10.
17. 11.3
18.5 12.65
19.75 14.2
20.9 15.8
21. 16.
```

A red line representing the User-Defined Failure surfaces is added in the main window. Close the "Nodes Table" and the "User-Defined Failure Surfaces" windows.

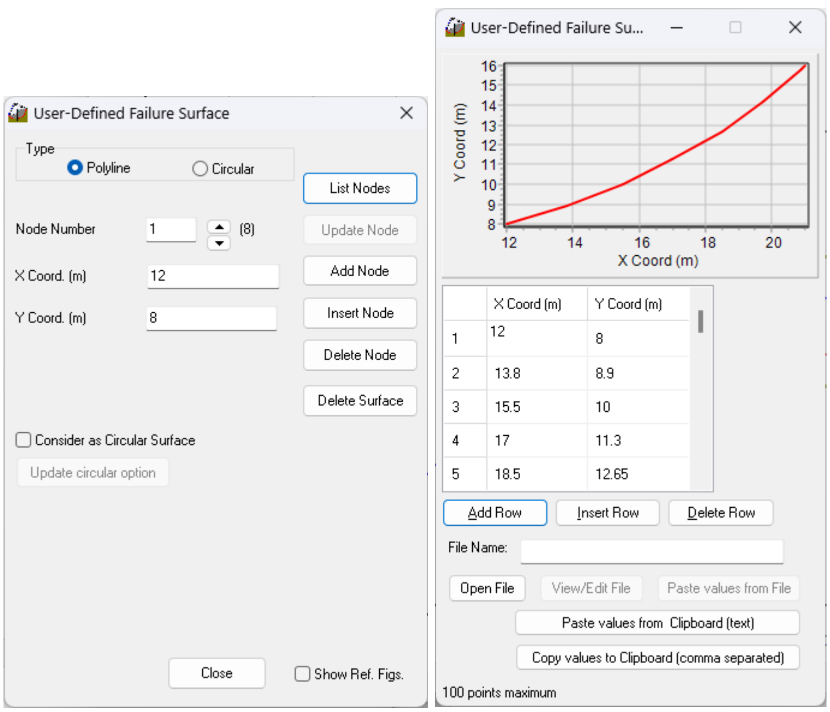


Figure 5.16 Input User-Defined Failure Surface for Example Problem 2.

5.3.2 Running the Analysis

Users can use the "*Run Analysis*" tab in the "*Computation*" menu or the ▶ icons to run the analysis. The program will switch to "Result" mode and the critical surface will be shown on the main window.

5.3.3 Output Data

Users can review the output data from the "*View output text*" tab in the "*Computation*" menu or the icons.

5.3.4 Graphical Results of Computer Analysis

The critical failure surface was marked in red, and the factor of safety is 1.224 (Figure 5.17.)

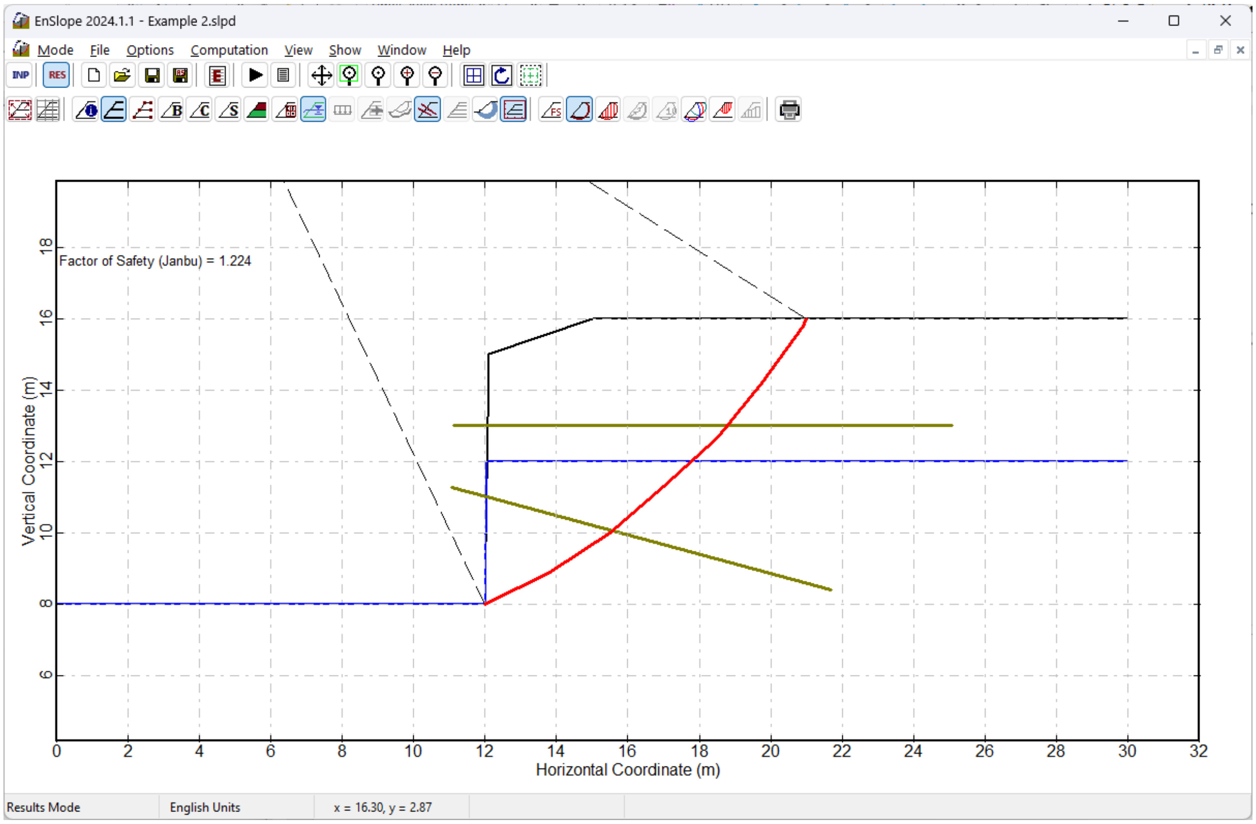


Figure 5.17 Plot of the trial surface of Example Problem 2.

5.4 Example Problem 3 (Block Failure)

The third example problem demonstrates the use of tiebacks for stabilizing an unstable earth slope. The slope profile is shown in Figure 5.18 and consists of a layer of compacted fill overlying a till deposit. Above the bedrock and below the till layer is a weak clay layer through which the slide movement occurs. The crest of the slope is subjected to an inclined surcharge load of 100 psf and a vertical surcharge load of 200 psf. In addition, a portion of the slope is saturated under the groundwater table.

The slope has been moving for several years and it appears that the failure is a sliding block type failure and that the failure surface passes through the weak clay stratum and exits near the toe of the slope. One solution to this problem is to install a single row of tiebacks into the slope which anchors into the bedrock. The anchor is placed at a horizontal spacing of 10 feet and is inclined at an angle of 40 degrees as measured from the horizontal. Each tieback is 45 ft long and carries a load of 300,000 lbs and bears against a 6 ft by 6 ft by 3 ft reinforced concrete pad.

The Block method will be used for the slope-stability analysis. Searching for the critical surface will be carried out within the weak layer defined by the blocks. The critical factor of safety for the overall stability of the tieback slope is over 1.5. The input data and output results are given in the following pages for reference.

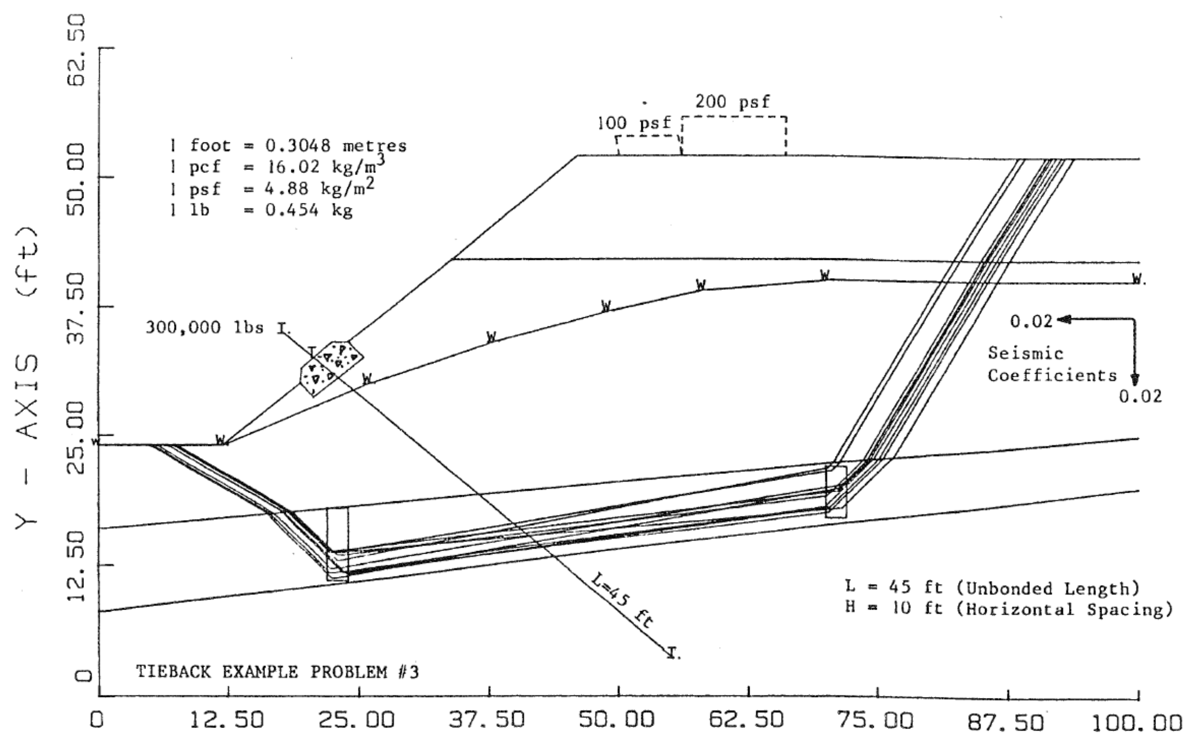


Figure 5.18 General soil description of Example Problem 3.

5.4.1 Input Data for Computer Analysis

Users can use the *Data* menu or the quick-access icon (in the 2nd row) to input data for analysis. It should be noted that data input can only be accessed in the *Input* mode. Users can select input mode from the *Mode* menu or click on the 

icon in the first row of the quick access icons. The steps below show data input using the *Data* menu.

Step 1: Enter project title: Click on the *Data* menu and select *Title*. Input information about the analyses, then click on "Save and Close". This field is limited to 1 line.

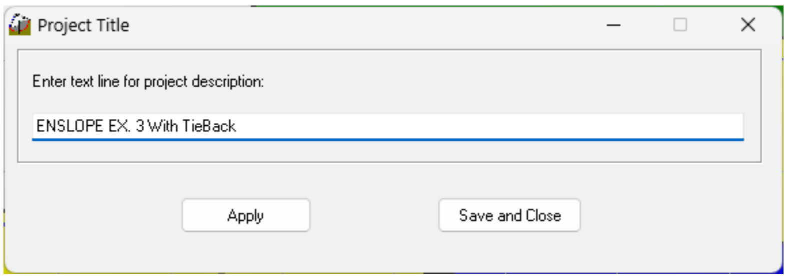


Figure 5.19 Input Project title for Example Problem 3.

Step 2: Enter slope segments: Click on the *Data* menu and select *Boundary Segments*. A pop-up window named "Boundary Segments" will appear (Figure 5.20). Users can choose to input the segment point-by-point or input the coordinates with a table. It is recommended to input the coordinates with a table by clicking on the "Nodes Table" to open the Node Coord window. Users can type in the coordinates and soil numbers shown below in the table. Alternatively, the data can be copied and pasted (click on "paste values from clipboard") into the table. The 3 numbers in each row represent the x, and y coordinates, and the material number.

```
0. 24. 2
12. 24. 2
19.5 30. 2
19.6 31.5 5
22.5 34. 5
24. 34. 5
34. 42. 2
46. 52. 1
100. 52. 1
```

There are 6 segments (soil layer lines) in this example. It should be noted that **the first segment must contain the entire surface of the slope.** Close the "Nodes Table" window. Click on "End Segment" to end the segment. Click on "Add Segments" to add the second layer line. Click on "Nodes Table", and copy the data below into the table.

```
34. 42. 2
100. 42. 2
```

Close the "Nodes Table" and the "Boundary Segments" windows. Click on "End Segment" to end the segment. Repeat these processes to add Segments 3 to 6 listed below.

Segment 3:

```
24. 34. 5
25.5 32.5 5
```

Segment 4:
```
19.5 30. 2
20.8 28.6 2
25.5 32.5 2
```

Segment 5:
```
0. 16. 3
100. 25. 3
```

Segment 6:
```
0. 8. 4
100. 20. 4
```

Six segment lines should be displayed on the main window.

Step 3: Enter piezometric surfaces: Click on the *Data* menu and select *Piezometric Surfaces*. A pop-up named "Piezometric Surfaces" will appear (Figure 5.21). Click on "Nodes Table", and copy the data below into the table.
```
0. 24.
12. 24.
26. 30.
38. 34.
49. 37.
58. 39.
70. 40.
100. 40.
```

Close the "Nodes Table" and the "Piezometric Surfaces" windows. A blue line representing the piezometric surfaces is added in the main window.

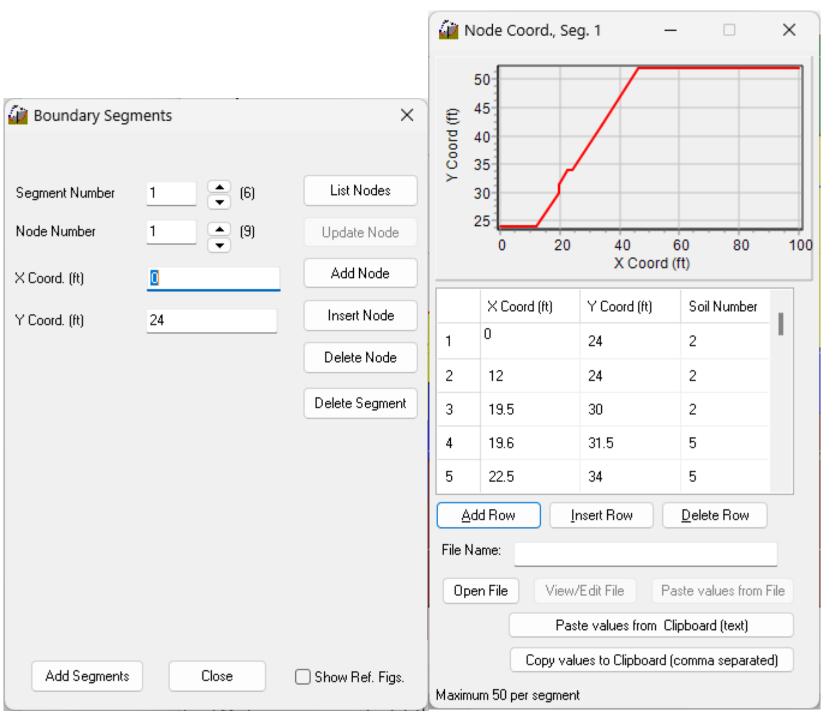


Figure 5.20 Input Boundary Segment 1 for Example Problem 3.

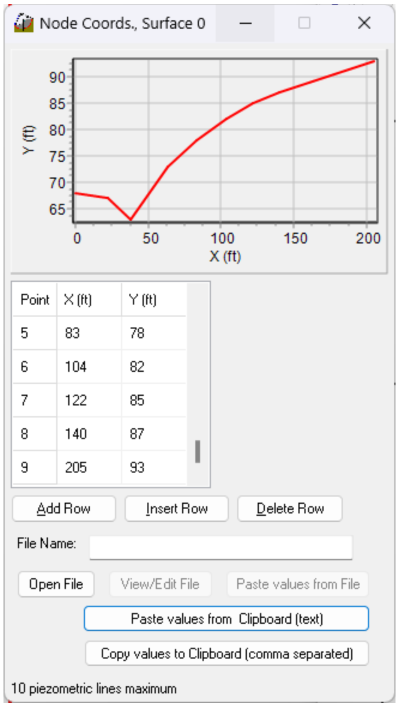


Figure 5.21 Input Piezometric Surfaces for Example Problem 3.

Step 4: Enter soil properties: Click on the *Data* menu and select *Soil Properties*. A pop-up named "Soil Properties" will appear (Figure 5.22). Input data is shown in the figure below for Soil #1. Click on "Add New Soil" to add a new soil layer and enter the Soil Properties listed in Table 5.1 for Soil #2, 3, 4, and 5. For Soil #2 click on "Enter Anisotropic Strength Data" to enter anisotropic strength (Figure 5.23). Click on "Close" to close the window.

Soil Number	Moist Unit Weight	Saturated Unit Weight	Isotropic Strength Intercept	Isotropic Strength Angle	Pore Pressure Parameter	Pore Pressure Constant	Piezometric Surface Number
1	120	125	400	26	0	0	1
2	122	127	850	30	0	0	1
3	115	120	475	0	0	0	1
4	144	147	0	45	0	0	1
5	150	150	0	0	0	0	1

Table 5.1 Soil Properties for Example Problem 3.

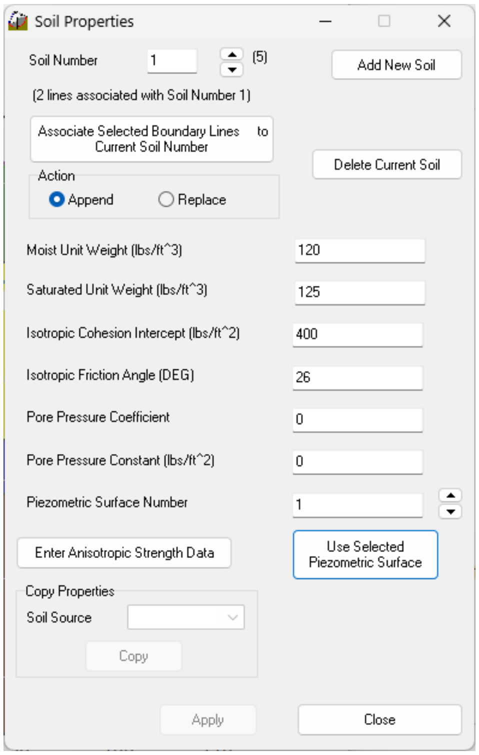


Figure 5.22 Input Soil Properties for Example Problem 3.

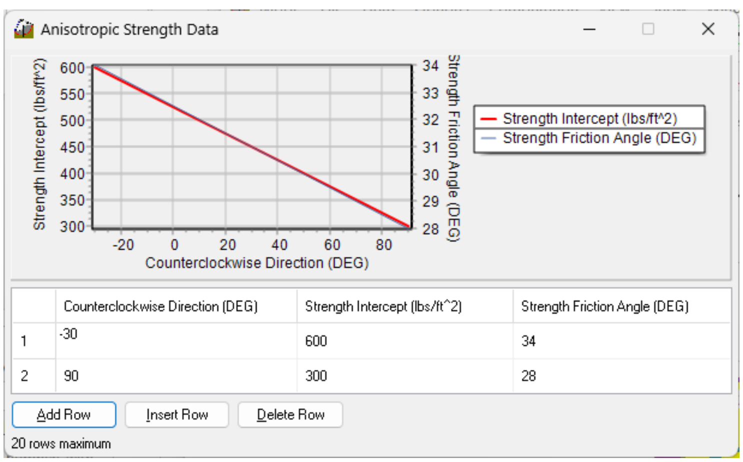


Figure 5.23 Input Anisotropic Strength Data for Example Problem 3.

Step 6: Enter surcharge loadings: Click on the *Data* menu and select *Surcharge Loading*. A pop-up named "Surcharge Loading" will appear (Figure 5.24). Input data is shown in the figure below for Surcharge Loadings #1 and #2. Click on "Add New Load" to add a new surcharge loading. Click on "Close" to close the window.

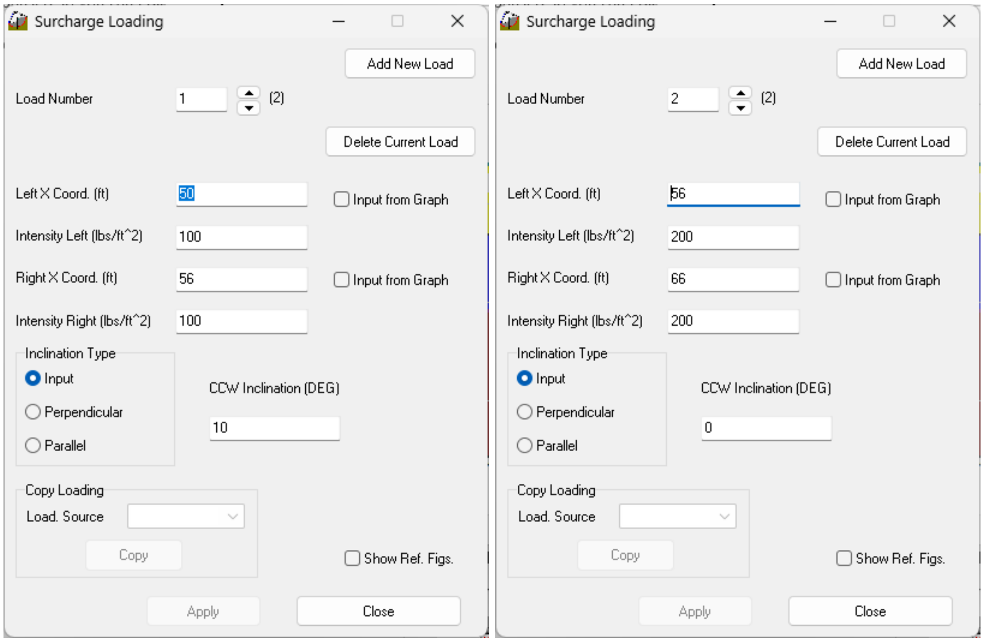


Figure 5.24 Input Surcharge Loadings for Example Problem 3.

Step 7: Enter earthquake loading coefficients: Click on the *Data* menu and select E*arthquake Loading Coefficients*. A pop-up named "Earthquake Loading Coefficients" will appear (Figure 5.25). Input data as shown in the figure below for earthquake loading coefficients. Click on "Close" to close the window.

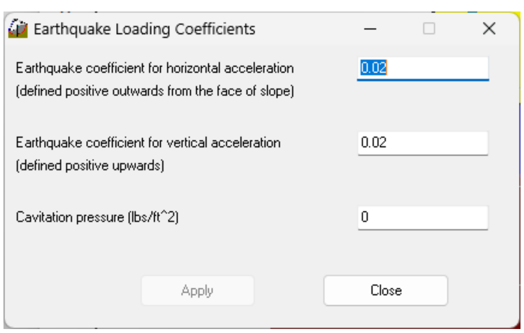


Figure 5.25 Input Earthquake Loading Coefficients for Example Problem 3.

Step 7: Enter tiebacks properties: Click on the *Data* menu and select *Tiebacks*. A pop-up named "Tiebacks" will appear. Input data is shown in Figure 5.26 for the added tieback. Click on "Close" to close the window.

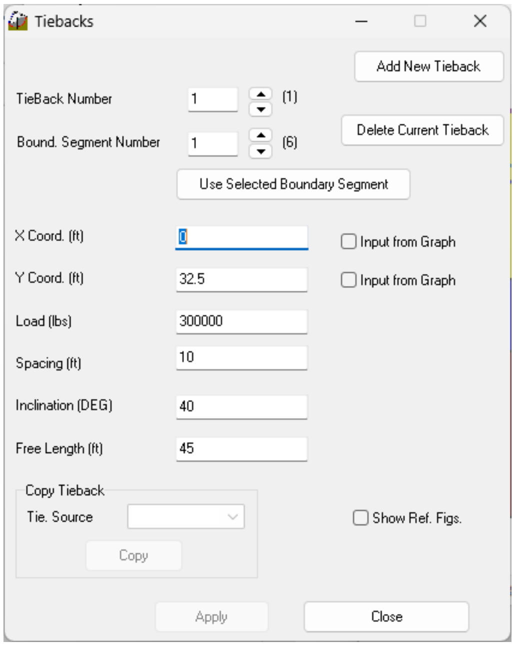


Figure 5.26   Input Tiebacks for Example Problem 3.

Step 8: Select the method of analysis: Click on the *Data* menu and select *Method of Analysis*. Select "Janbu*'s Method*" for the analyses.

Step 7: Select the failure surface search: Click on the *Data* menu and select "*Failure Surface Search*". Select "Generate Block Failure Surface Search", and a pop-up named "*Search by Block Method*" will appear. Enter data as shown in Figure 5.27 for Block #1. As shown in the figure, a purple box will be drawn in the main window representing the search Block #1 (Pointed out with a red arrow). Enter data as shown in Figure 5.28 for Block #2. Click on "Close" to close the window.

5.4.2 Running the Analysis

Users can use the "*Run Analysis*" tab in the "*Computation"* menu or the icons to run the analysis. The program will switch to "Result" mode and the critical surface will be shown on the main window.

5.4.3 Output Data

Users can review the output data from the "*View output text*" tab in the "*Computation"* menu or the icons.

5.4.4 Graphical Results of Computer Analysis

The critical failure surface is marked in red, and the factor of safety is 1.467. It is useful to plot all trial surfaces together for comparison as shown in Figure 5.29. Click on the *Show* menu and select *All Trial Surfaces*. Double-click in the area of the legend to change the limits and/or increment.

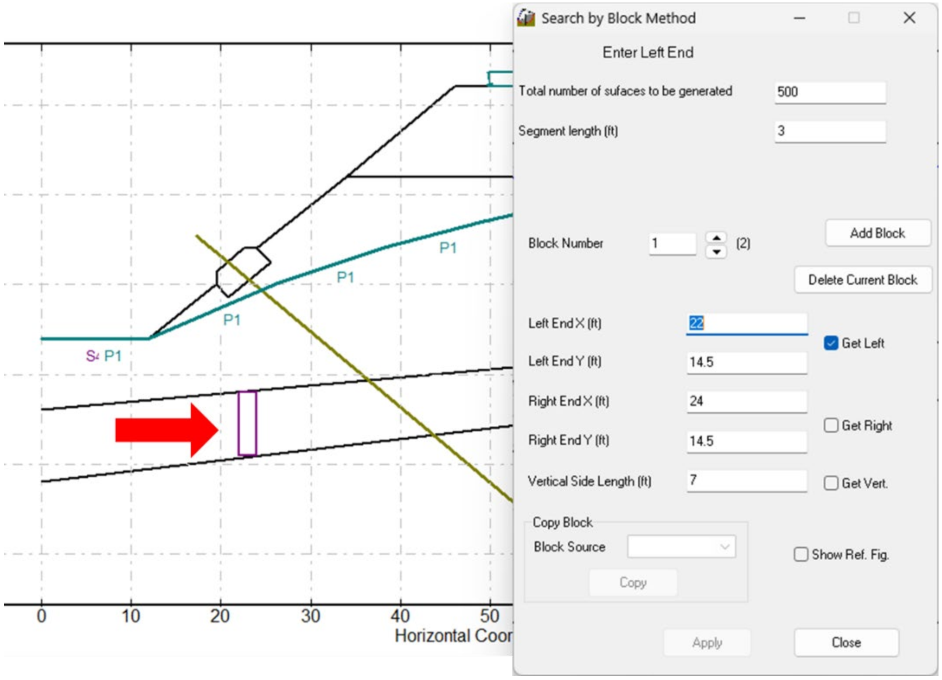


Figure 5.27 Block Failure Surface Search Block #1 for Example Problem 3.

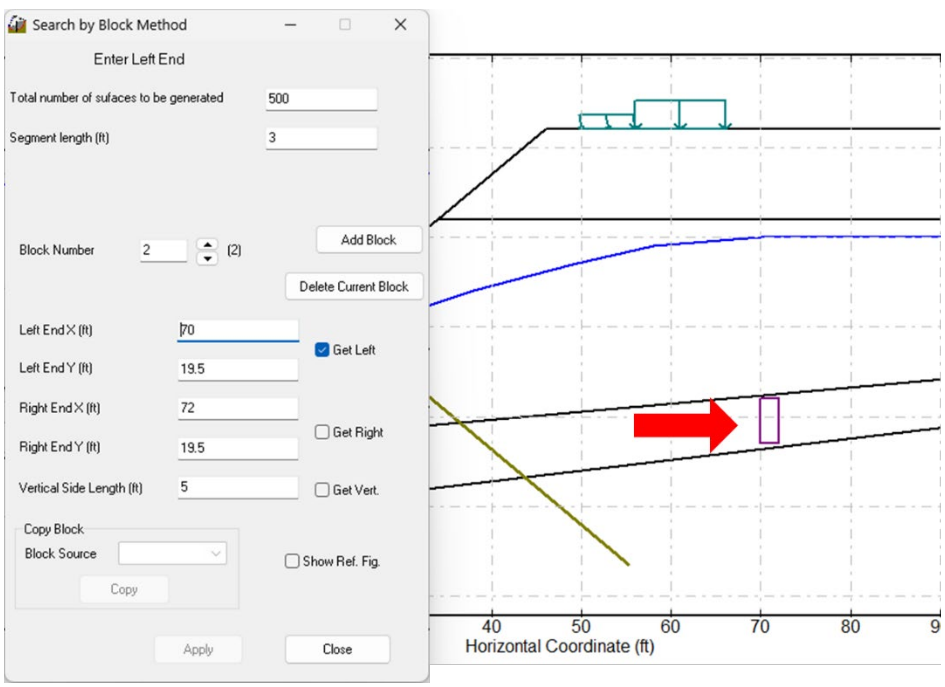


Figure 5.28 Block Failure Surface Search Block #2 for Example Problem 3.

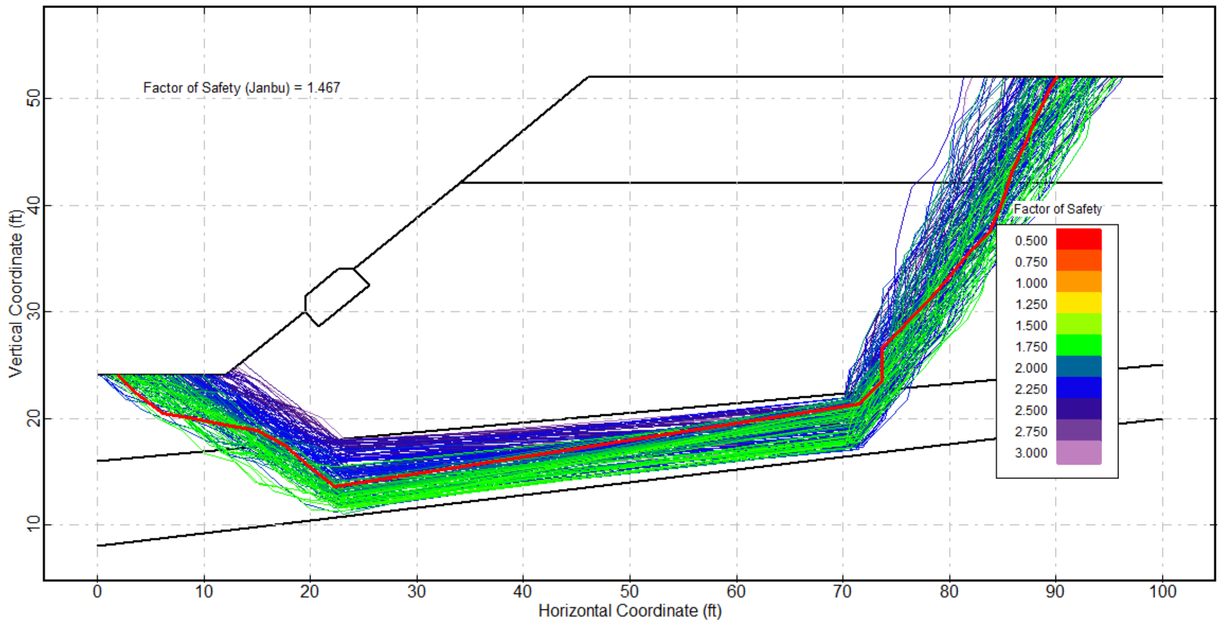


Figure 5.29 Plot of the most critical failure surface and all trial surfaces of Example Problem 3.

5.5 Example Problem 4 (Reinforced Earth Slope)

The fourth example problem demonstrates the analysis of an embankment constructed on soft ground reinforced with 12 layers of reinforcement. The slope profile is shown in Figure 5.30. The embankment soil has been arbitrarily assigned soil type number 1, which has weak shear parameters (c' = 5.79 kPa, ϕ = 27 deg, and γ = 19.63 kN/m^3). The foundation soil below the embankment is soil type number 2, which has little stronger shear parameters (c' = 9.58 kPa, ϕ = 30 deg, and γ = 18.84 kN/m^3).

Tensile reinforcing layers provide a resisting moment which increases the embankment stability. This effect was incorporated into the simplified Bishop method. The methodology for considering the resistance components from the reinforcing layers can be found in the technical manual. To use the reinforcing option, the location of each layer is specified by a series of x, and y coordinates starting at the left end of the reinforcement and moving to the right as indicated in Figure 5.30. In a typical application, the left end of the layer would be at the embankment toe or the face of the slope and would extend across the full width of the embankment.

The available force and orientation of the force are specified at each point defining the reinforcing layer. The orientation of the force is specified by the inclination factor. The inclination factor varies from 0.0 which specifies that the force acts in the direction of the reinforcement to 1.0 which specifies that it acts along the slip surface. The Simplified Bishop method is used for the slope-stability analysis on the user-specified slip surface. It should be noted that this example demonstrates the process of determining the safety factor of a user-defined surface. This user-defined surface, however, is not the critical surface.

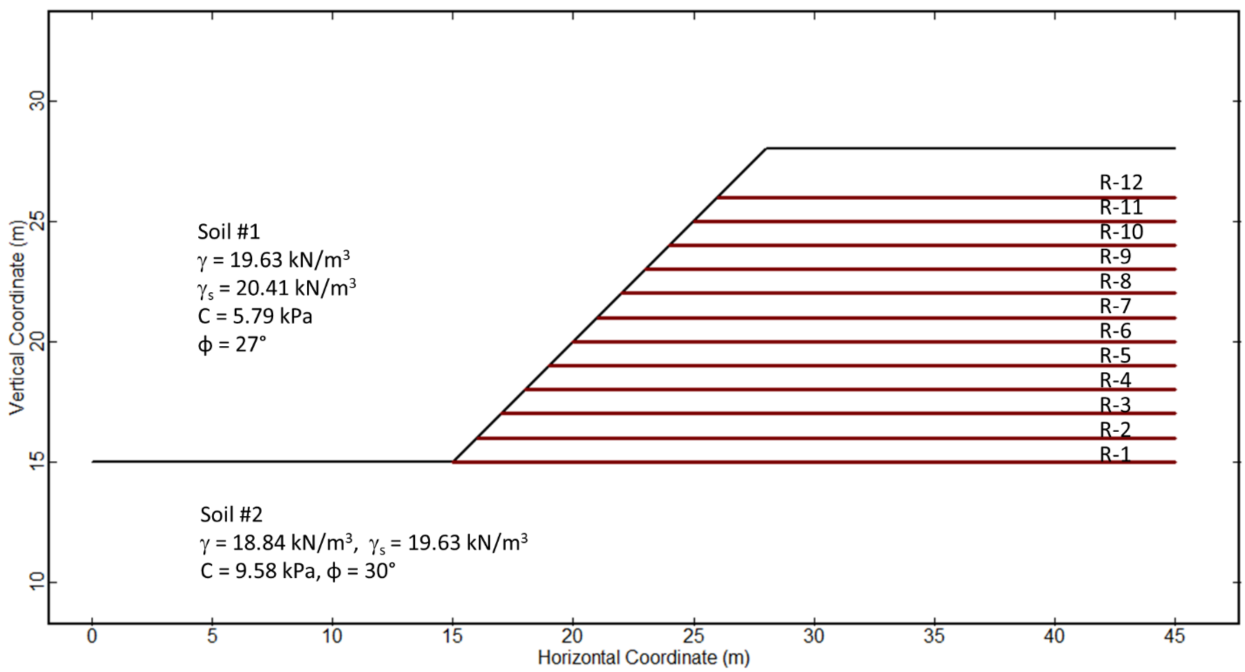


Figure 5.30 General soil description of Example Problem 4.

5.5.1 Input Data for Computer Analysis

Users can use the *Data* menu or the quick-access icon (in the 2nd row) to input data for analysis. It should be noted that data input can only be accessed in the *Input* mode. Users can select input mode from the *Mode* menu or click on the INP icon in the first row of the quick access icons. The steps below show data input using the *Data* menu.

Step 1: Enter project title: Click on the *Data* menu and select *Title*. Input information about the analyses, then click on "Save and Close". This field is limited to 1 line.

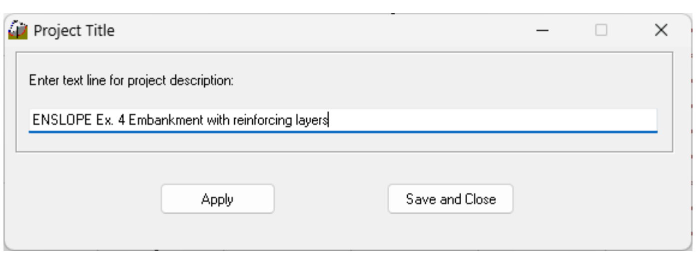


Figure 5.31 General soil description of Example Problem 2.

Step 2: Enter slope segments: Click on the *Data* menu and select *Boundary Segments*. A pop-up window named "Boundary Segments" will appear (Figure 5.32). Users can choose to input the segment point-by-point or input the coordinates with a table. It is recommended to input the coordinates with a table by clicking on the "Nodes Table" to open the Node Coord window. Users can type in the coordinates and soil numbers shown below in the table. Alternatively, the data can be copied and pasted (click on "paste values from clipboard") into the table. The 3 numbers in each row represent the x, and y coordinates, and the material number.

```
0. 15. 2
15. 15. 2
28. 28. 1
45. 28. 1
```

There are 2 segments (soil layer lines) in this example. It should be noted that **the first segment must contain the entire surface of the slope.** Close the “Nodes Table” window. Click on “End Segment” to end the segment. Click on “Add Segments” to add the second layer line. Click on “Nodes Table”, and copy the data below into the table.

```
15. 15. 2
45. 15. 2
```

Close the “Nodes Table” and the “Boundary Segments” windows. Click on “End Segment” to end the segment. Two segment lines should be displayed on the main window.

Step 3: Enter soil properties: Click on the *Data* menu and select *Soil Properties*. A pop-up named “Soil Properties” will appear. Input data is shown in Figure 5.33 for Soils #1 and #2. Click on “Close” to close the window.

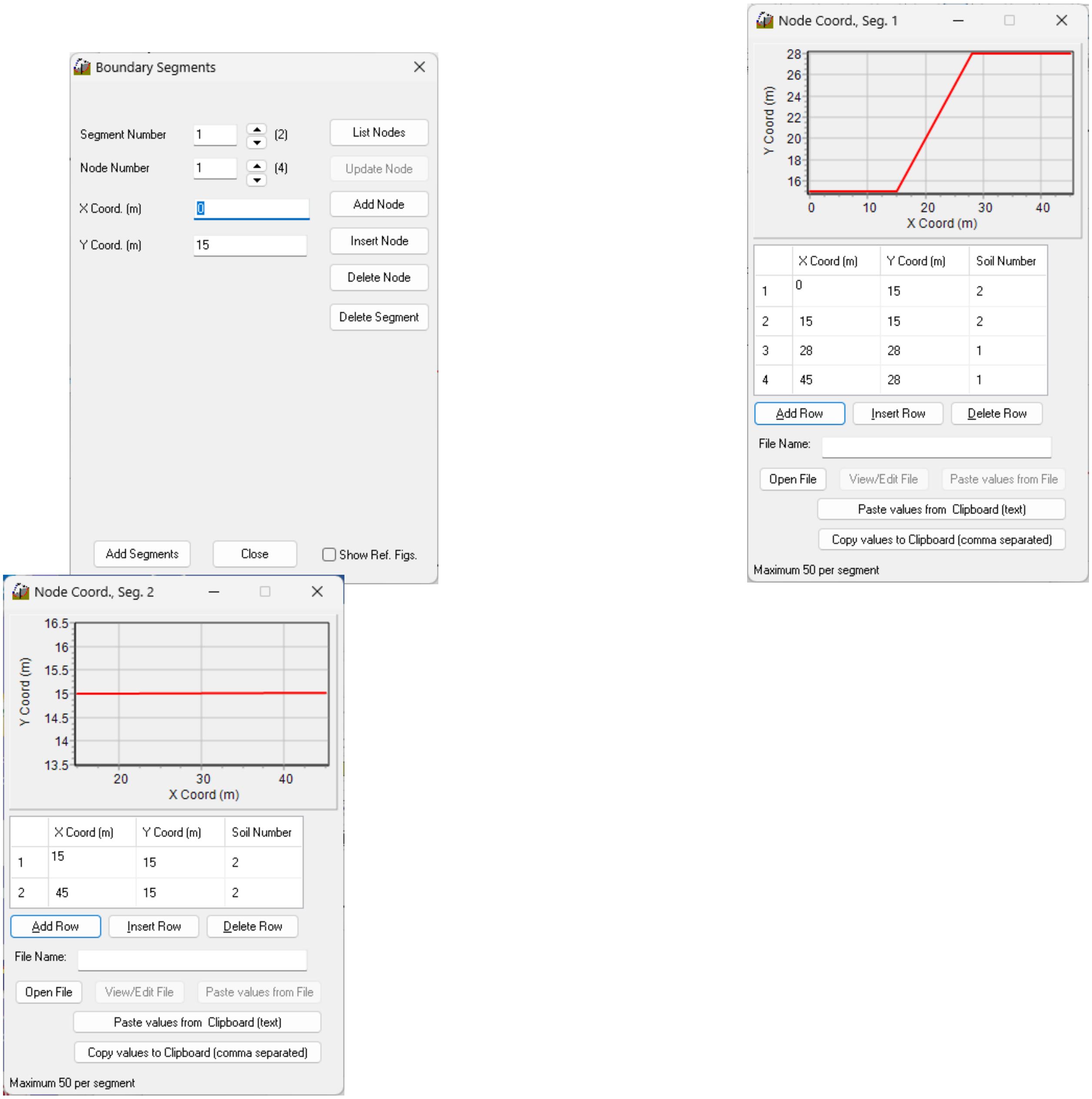


Figure 5.32 Input Boundary Segments for Example Problem 4.

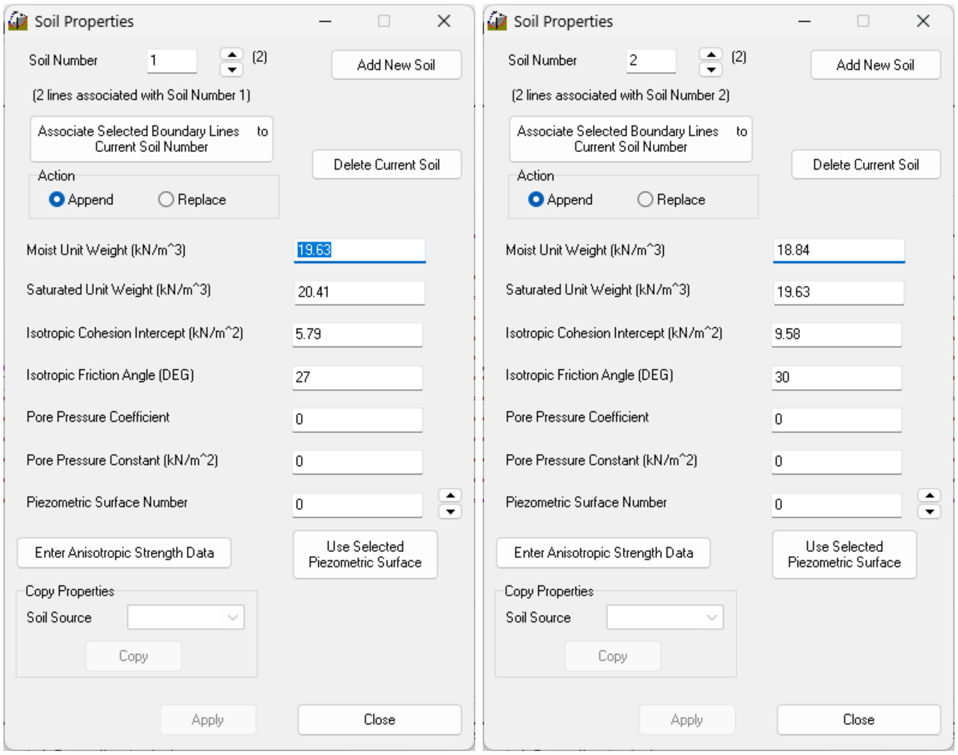


Figure 5.33 Input Soil Properties for Example Problem 4.

Step 4: Enter reinforcements: Click on the *Data* menu and select *Reinforcement Layers*. A pop-up named "Reinforcement Layers" will appear (Figure 5.33). Click on the "Nodes Table" to open the Node Coord window. Users can type in the coordinates and soil numbers shown below in the table. Alternatively, the data can be copied and pasted (click on "paste values from clipboard") into the table. The 5 numbers in each row represent the x, and y coordinates, axial force, shear force, and inclination factor.

```
15. 15. 0. 0. 0.
19. 15. 7.295 0. 0.
45. 15. 7.295 0. 0.
```

Close the "Nodes Table" window. Click on "Add Layer" to add another layer of reinforcement. Repeat these steps to add Reinforcement Layer #2 to #12.

Layer #2:

```
16. 16. 0. 0. 0.
20. 16. 7.295 0. 0.
45. 16. 7.295 0. 0.
```

Layer #3:

```
17. 17. 0. 0. 0.
21. 17. 7.295 0. 0.
45. 17. 7.295 0. 0.
```

Layer #4:

```
18. 18. 0. 0. 0.
22. 18. 7.295 0. 0.
45. 18. 7.295 0. 0.
```

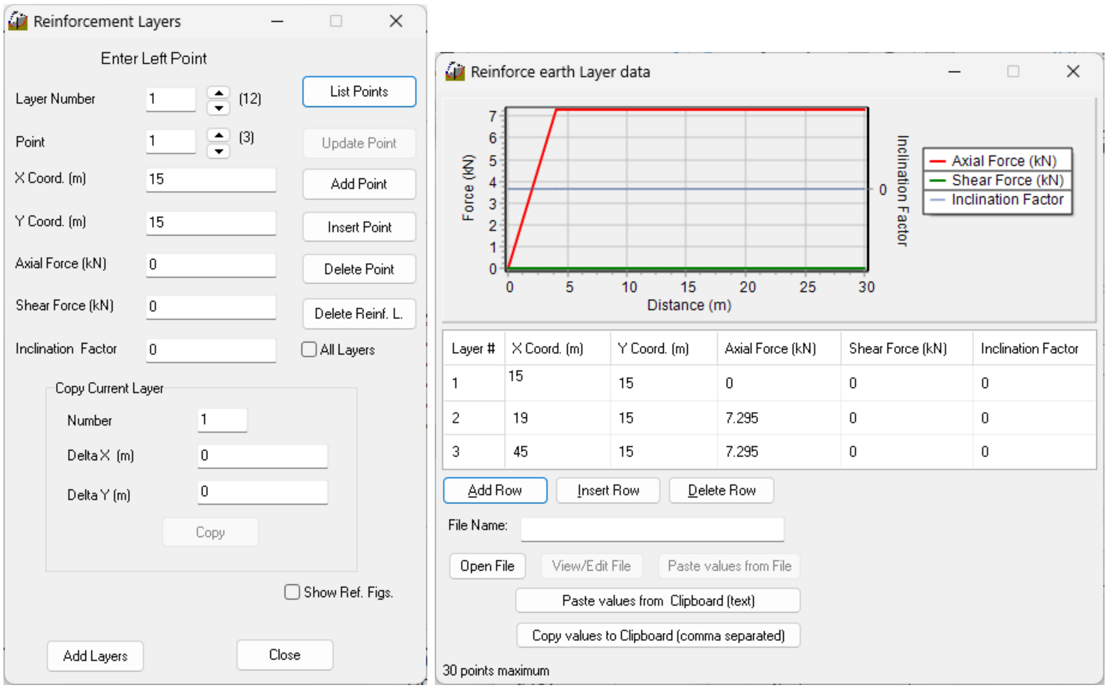


Figure 5.34 Input Reinforcement Layers for Example Problem 4.

Layer #5:

```
19. 19. 0. 0. 0.
23. 19. 7.295 0. 0.
45. 19. 7.295 0. 0.
```

Layer #6:

```
20. 20. 0. 0. 0.
24. 20. 7.295 0. 0.
45. 20. 7.295 0. 0.
```

Layer #7:

```
21. 21. 0. 0. 0.
25. 21. 7.295 0. 0.
45. 21. 7.295 0. 0.
```

Layer #8:

```
22. 22. 0. 0. 0.
26. 22. 7.295 0. 0.
45. 22. 7.295 0. 0.
```

Layer #9:

```
23. 23. 0. 0. 0.
27. 23. 7.295 0. 0.
45. 23. 7.295 0. 0.
```

Layer #10:

```
24. 24. 0. 0. 0.
28. 24. 7.295 0. 0.
45. 24. 7.295 0. 0.
```

Layer #11:

```
25. 25. 0. 0. 0.
29. 25. 7.295 0. 0.
45. 25. 7.295 0. 0.
```

Layer #12:

```
26. 26. 0. 0. 0.
30. 26. 7.295 0. 0.
45. 26. 7.295 0. 0.
```

Step 6: Select the method of analysis: Click on the *Data* menu and select *Method of Analysis*. Select "*Bishop's Method*"

Step 7: Select the failure surface search: Click on the *Data* menu and select "*Failure Surface Search*". Select "*User-Defined Failure Surface*", and a pop-up named "User-Defined Failure Surface" will appear (Figure 5.7). Click on the "Nodes Table" to open the Node Coord window. Copied and pasted the data below into the table.

```
15. 15.
17. 15.4
18.9 15.9
20.8 16.5
22.7 17.3
24.5 18.2
26.2 19.1
27.9 20.2
29.5 21.4
31. 22.7
32.5 24.
33.9 25.5
35.1 27.
35.8 28.
```

Click on "Close" to close the window.

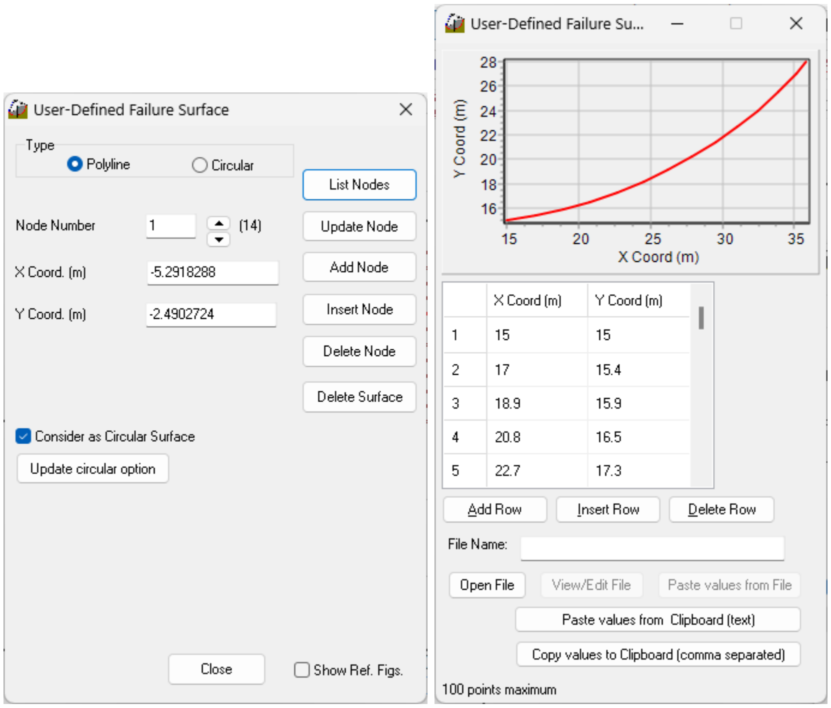


Figure 5.35 User-Defined Failure Surface Parameters for Example Problem 4.

5.5.2 Running the Analysis

Users can use the "*Run Analysis*" tab in the "*Computation*" menu or the icons to run the analysis. The program will switch to "Result" mode and the critical surface will be shown on the main window.

5.5.3 Output Data

Users can review the output data from the "*View output text*" tab in the "*Computation*" menu or the icons.

5.5.4 Graphical Results of Computer Analysis

As shown in Figure 5.36, the factor of safety is 1.131. The failure surface was plotted in red in the figure. It should be noted that this example demonstrates the process of determining the safety factor of a user-defined surface. This surface, however, is not the critical surface.

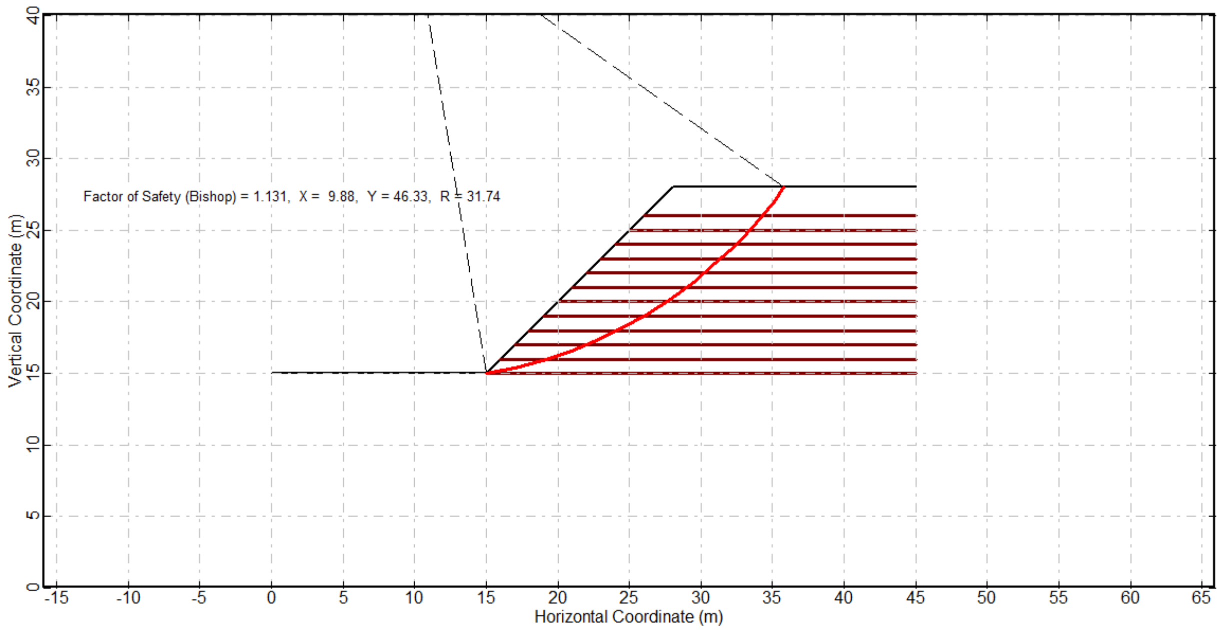


Figure 5.36 Plot of the user-defined failure surface of Example Problem 4.

5.6 Example Problem 5 (Multi-Layer Slope, SI units)

The fifth example problem demonstrates the use of tiebacks for stabilizing an unstable earth slope. The slope profile consists of three layers of soft to medium stiff clays overlying a sand deposit. The slope profile is shown in Figure 5.37. The factor of safety against the slope failure based on the Simplified Bishop Method is 0.888 as shown in the figure. Two tiebacks are considered to increase the stability of the slope. The locations of each tieback are shown in Figure 5.38. The Simplified Bishop method was used for analyzing the slope with the support of tiebacks. The factor of safety against failure increases from 0.888 to 1.120 as shown in Figure 5.39. All the trial surfaces, which cover an extensive area, are also plotted in the same figure for reference.

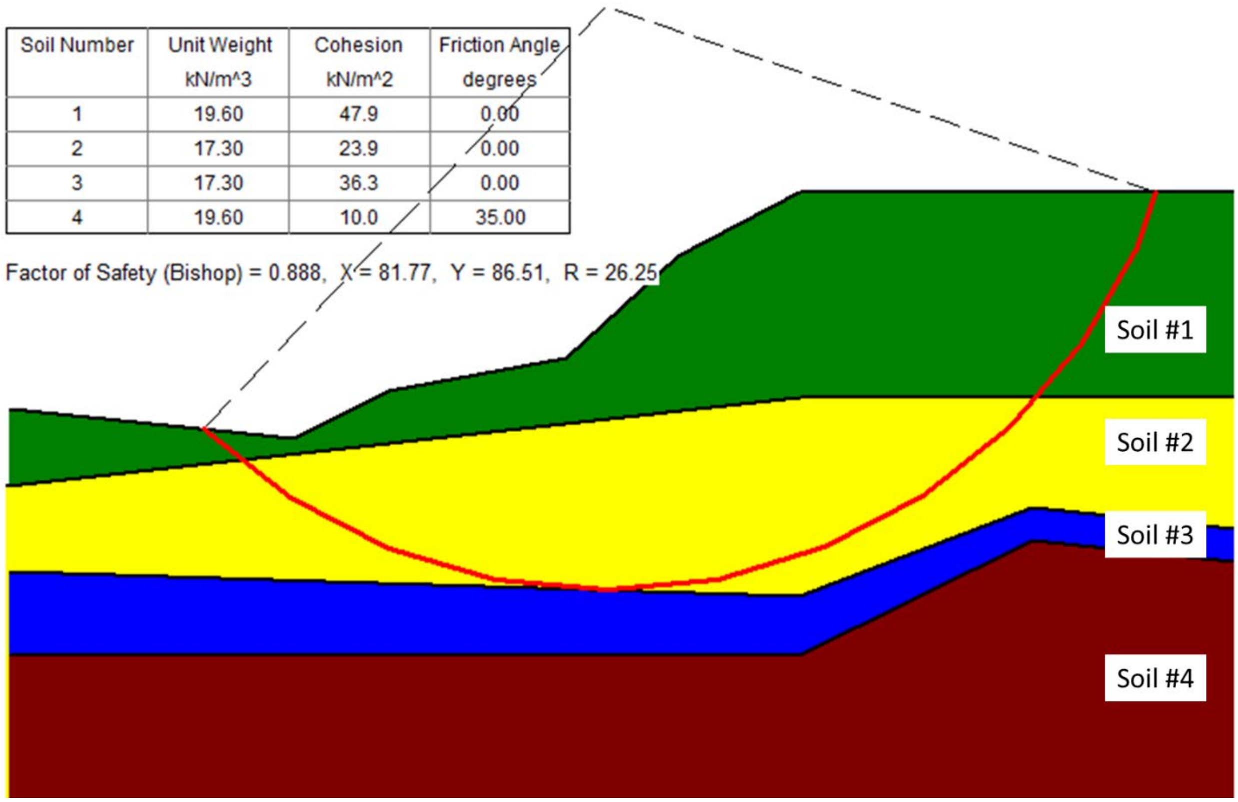


Figure 5.37 The most critical slope (F.S. = 0.888) of Example Problem 5 without tiebacks.

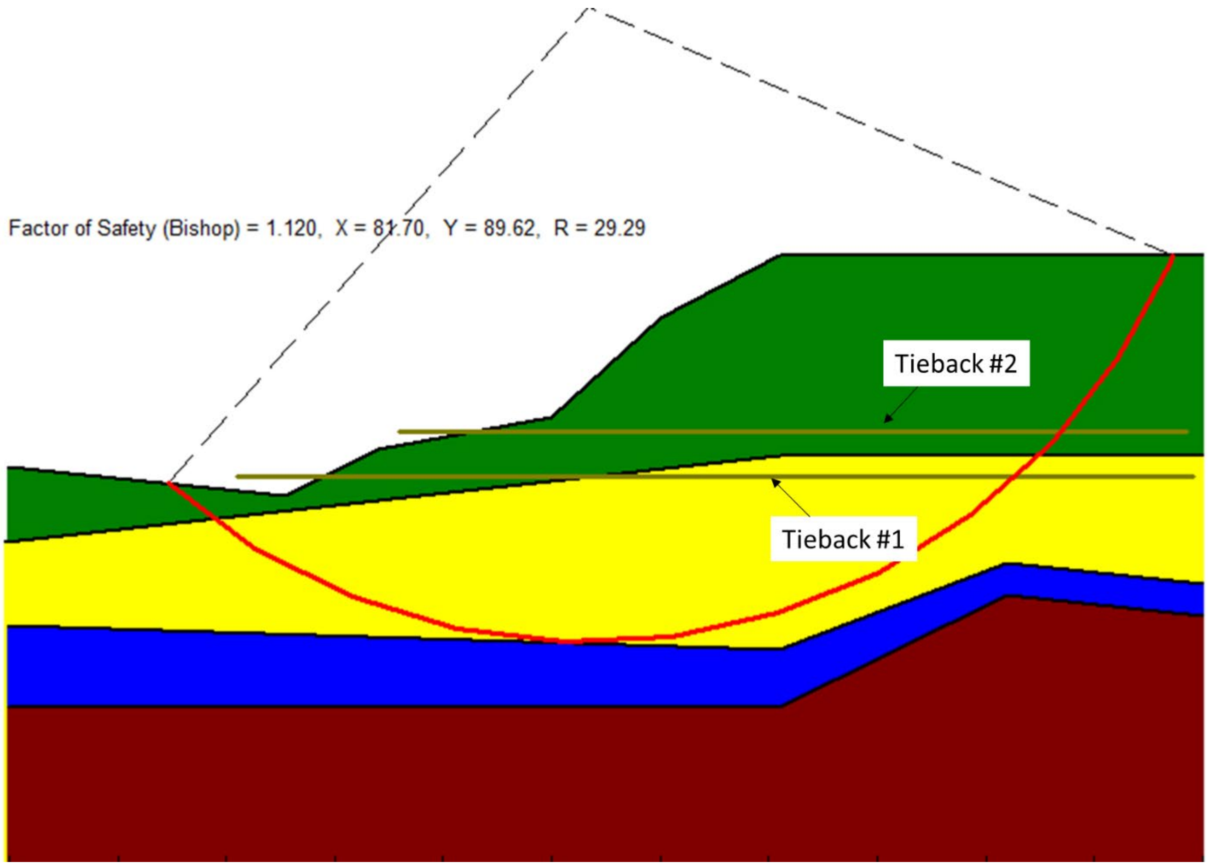


Figure 5.38 The most critical slope (F.S. = 1.120) of Example Problem 5 with support from two tiebacks .

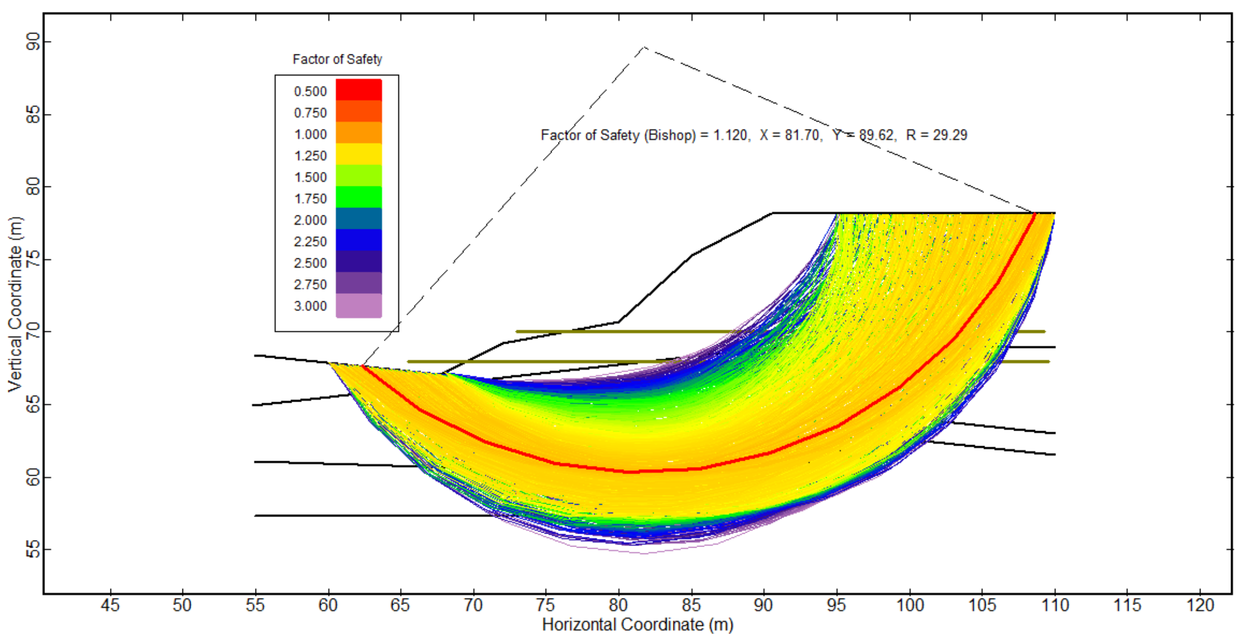


Figure 5.39 All trial surfaces of Example Problem 5.

5.6.1 Input Data for Computer Analysis

Users can use the *Data* menu or the quick-access icon (in the 2nd row) to input data for analysis. It should be noted that data input can only be accessed in the *Input* mode. Users can select input mode from the *Mode* menu or click on the INP icon in the first row of the quick access icons. The steps below show data input using the *Data* menu.

Step 1: Enter project title: Click on the *Data* menu and select *Title*. Input information about the analyses, then click on "Save and Close". This field is limited to 1 line.

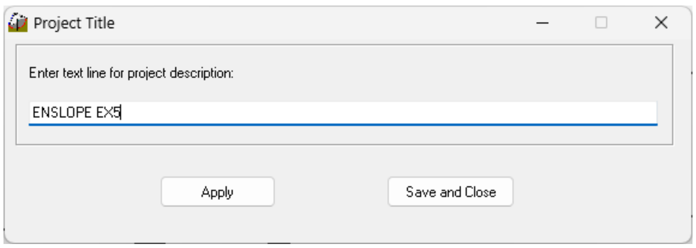


Figure 5.40 Input Project title for Example Problem 5.

Step 2: Enter slope segments: Click on the *Data* menu and select *Boundary Segments*. A pop-up window named "Boundary Segments" will appear (Figure 5.41). Users can choose to input the segment point-by-point or input the coordinates with a table. It is recommended to input the coordinates with a table by clicking on the "Nodes Table" to open the Node Coord window. Users can type in the coordinates and soil numbers shown below in the table. Alternatively, the data can be copied and pasted (click on "paste values from clipboard") into the table. The 3 numbers in each row represent the x, and y coordinates, and the material number.

```
54.9 68.4 1
67.7 67.1 1
72. 69.2 1
80. 70.7 1
85. 75.3 1
90.5 78.2 1
110. 78.2 1
```

There are 4 segments (soil layer lines) in this example. It should be noted that **the first segment must contain the entire surface of the slope.** Close the "Nodes Table" window. Click on "End Segment" to end the segment. Click on "Add Segments" to add the second layer line. Click on "Nodes Table", and copy the data below into the table.

```
54.8 64.9 2
90.5 68.9 2
110. 68.9 2
```

Close the "Nodes Table" and the "Boundary Segments" windows. Repeat these processes to add Segments 3 to 4 listed below.

Segment 3:

```
54.9 61.1 3
90.5 60. 3
101. 64. 3
110. 63. 3
```

Segment 4:

```
54.9 57.3 4
90.5 57.3 4
101. 62.5 4
110. 61.5 4
```

Click on “End Segment” to end the segment. Four segment lines should be displayed on the main window.

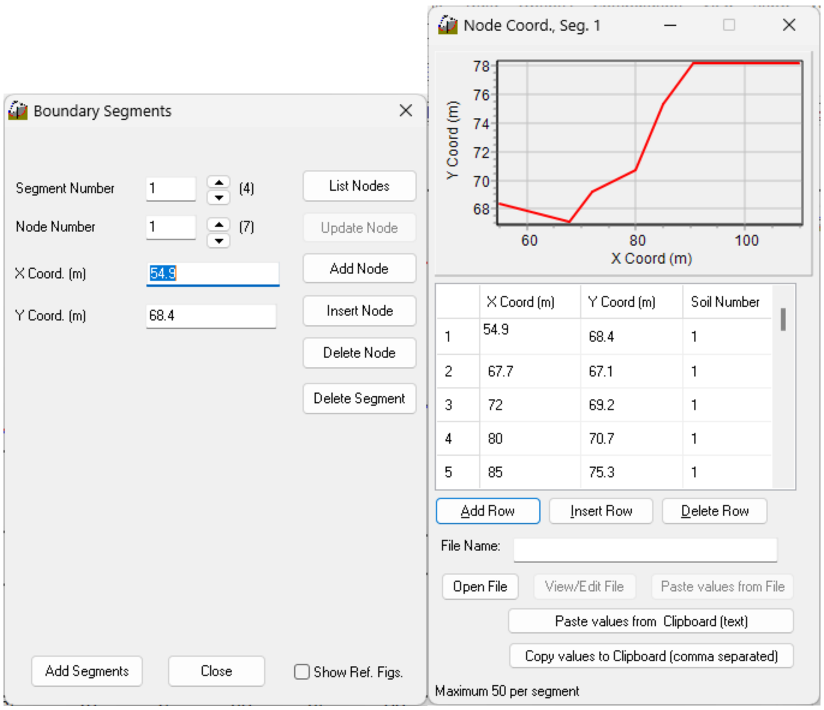


Figure 5.41 Input Boundary Segments for Example Problem 5.

Step 3: Enter piezometric surfaces: Click on the *Data* menu and select *Piezometric Surfaces*. A pop-up named “Piezometric Surfaces” will appear (Figure 5.42). Click on “Nodes Table”, and copy the data below into the table.

```
55. 67.1
63. 67.1
110. 70.
```

Close the “Nodes Table” and the “Piezometric Surfaces” windows. A blue line representing the piezometric surfaces is added in the main window.

Step 4: Enter soil properties: Click on the *Data* menu and select *Soil Properties*. A pop-up named “Soil Properties” will appear (Figure 5.43). Input data is shown in the figure below for Soil #1. Click on “Add New Soil” to add a new soil layer and enter the Soil Properties listed in Table 5.2 for Soil #2, 3, and 4.

Soil Number	Moist Unit Weight	Saturated Unit Weight	Isotropic Strength Intercept	Isotropic Strength Angle	Pore Pressure Parameter	Pore Pressure Constant	Piezometric Surface Number
1	19.6	19.6	47.9	0	0	0	1
2	17.3	17.3	23.9	0	0	0	1
3	17.3	17.3	36.3	0	0	0	1
4	19.6	19.6	10	35	0	0	1

Table 5.2 Soil Properties for Example Problem 5.

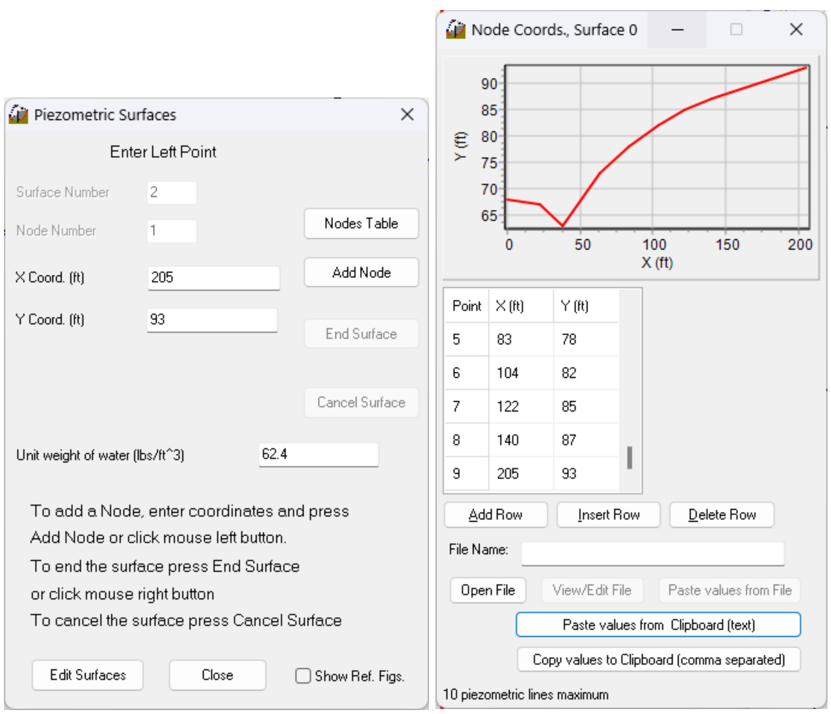


Figure 5.42 Input Piezometric Surfaces for Example Problem 5.

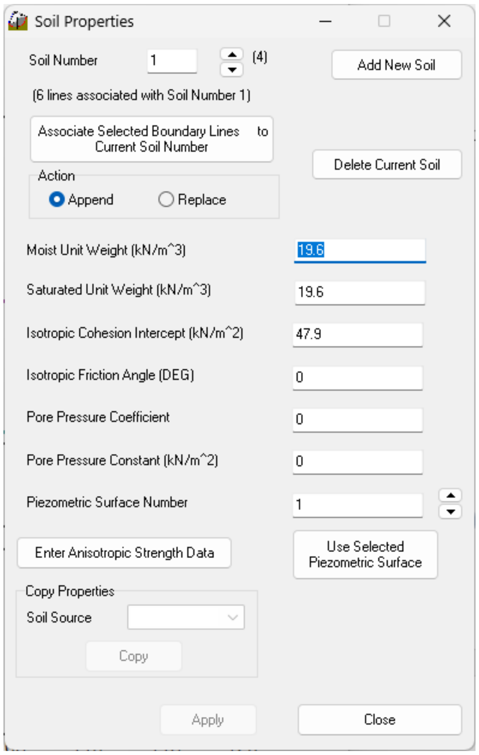
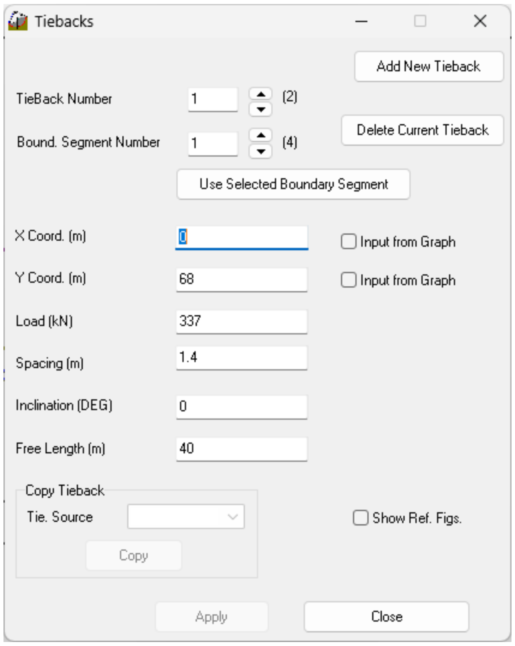


Figure 5.43 Input Soil Properties for Example Problem 5.

Step 5: Enter tieback properties: Click on the *Data* menu and select *Tiebacks*. A pop-up named "Tiebacks" will appear (Figure 5.44). Input data is shown in the figure below for Tieback #1 and Tieback #2.

Step 6: Select the method of analysis: Click on the *Data* menu and select *Method of Analysis*. Select "*Bishop's Method*"

Step 7: Select the failure surface search: Click on the *Data* menu and select "*Failure Surface Search*". Select "Generate Circular Failure Surface Search", and a pop-up named "*Circular Failure Surface Search*" will appear (Figure 5.45). Enter data as shown in the figure below for failure surface search. Click on "Close" to close the window.



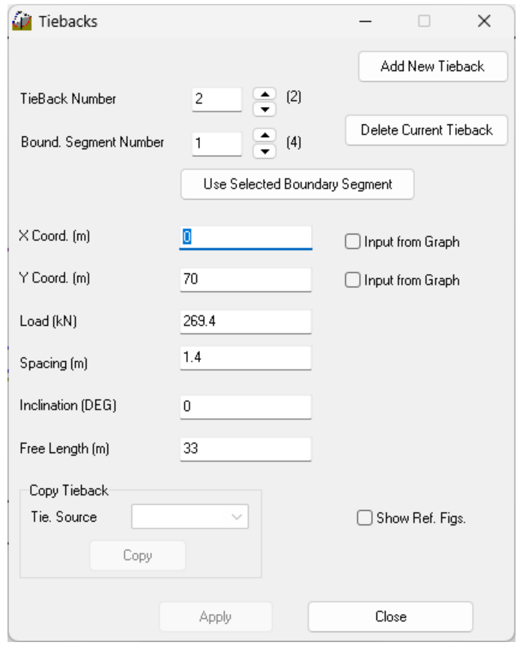


Figure 5.44 Input Tieback Properties for Example Problem 5.

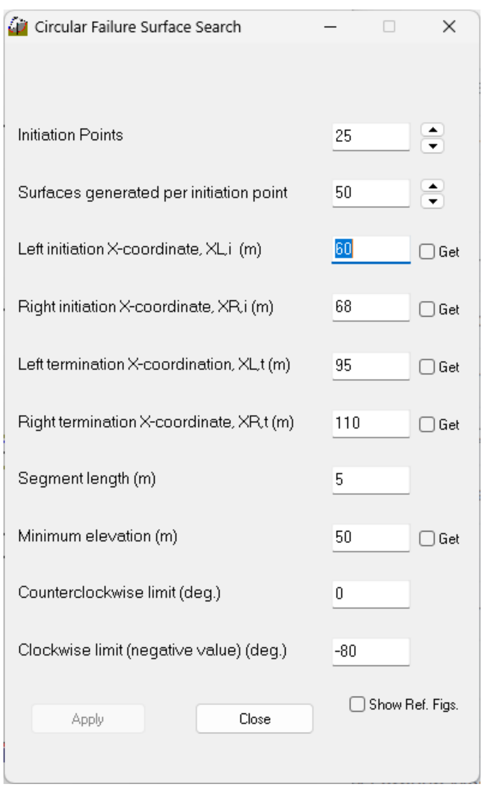


Figure 5.45 Circular Failure Surface Search Parameters for Problem 5.

5.6.2 Running the Analysis

Users can use the “*Run Analysis*” tab in the “*Computation”* menu or the icons to run the analysis. The program will switch to “Result” mode and the critical surface will be shown on the main window.

5.6.3 Output Data

Users can review the output data from the “*View output text*” tab in the “*Computation”* menu or the icons.

5.6.4 Graphical Results of Computer Analysis

The critical failure surface is marked in red, and the factor of safety is 1.120. It is useful to plot all trial surfaces together for comparison as shown in Figure 5.39.

5.7 Example Problem 6 (Complicated Slope Geometry)

The sixth example problem demonstrates an application of complicated soil conditions and geometry with global, local, and block failure surfaces. The layers of each sectional line for defining the soil profile and surface are shown in Figure 5.46. An area with graben debris is shown in gray color in the figure. The trial surface limit is at y = 0.0 m.

The factor of safety against the overall slope failure based on the Simplified Bishop Method is 1.287 for the overall stability as shown in Figure 5.47. The safety factor of the sliding surface through layer #4 using the Simplified Janbu Method is 1.024 as shown in Figure 5.48. However, the local safety factor of the top two layers is only 0.409 as shown in Figure 5.49.

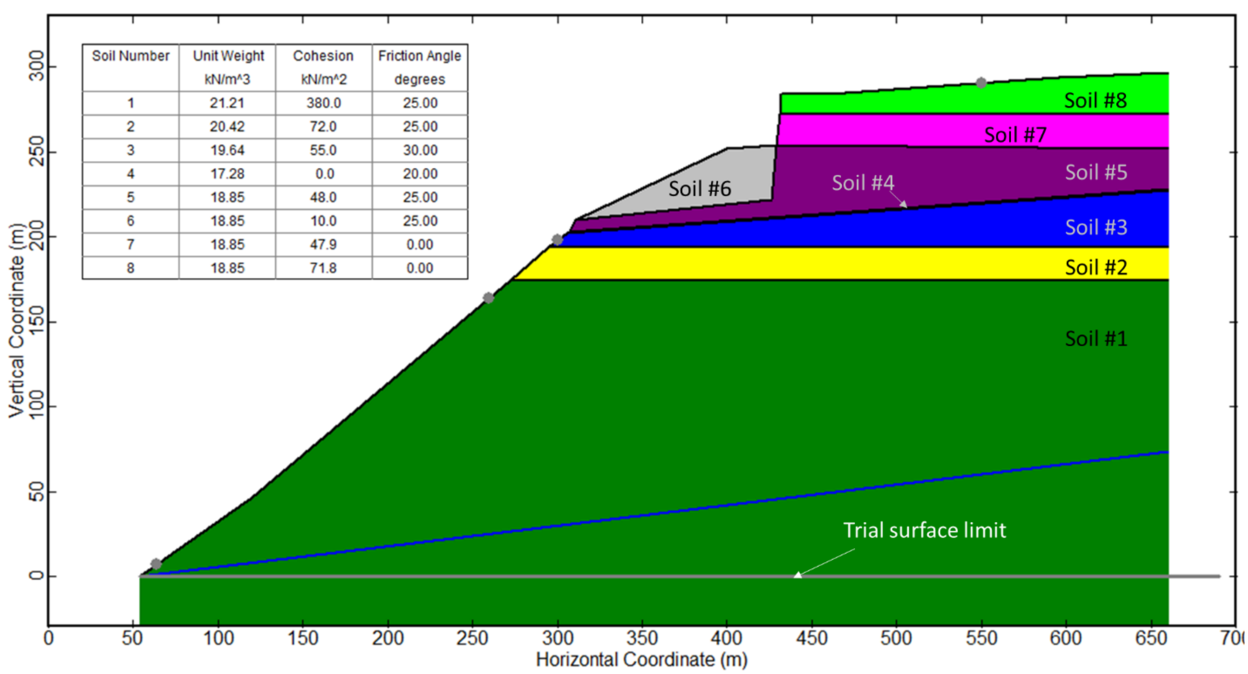


Figure 5.46 Layout of soil layer numbers of Example Problem 6.

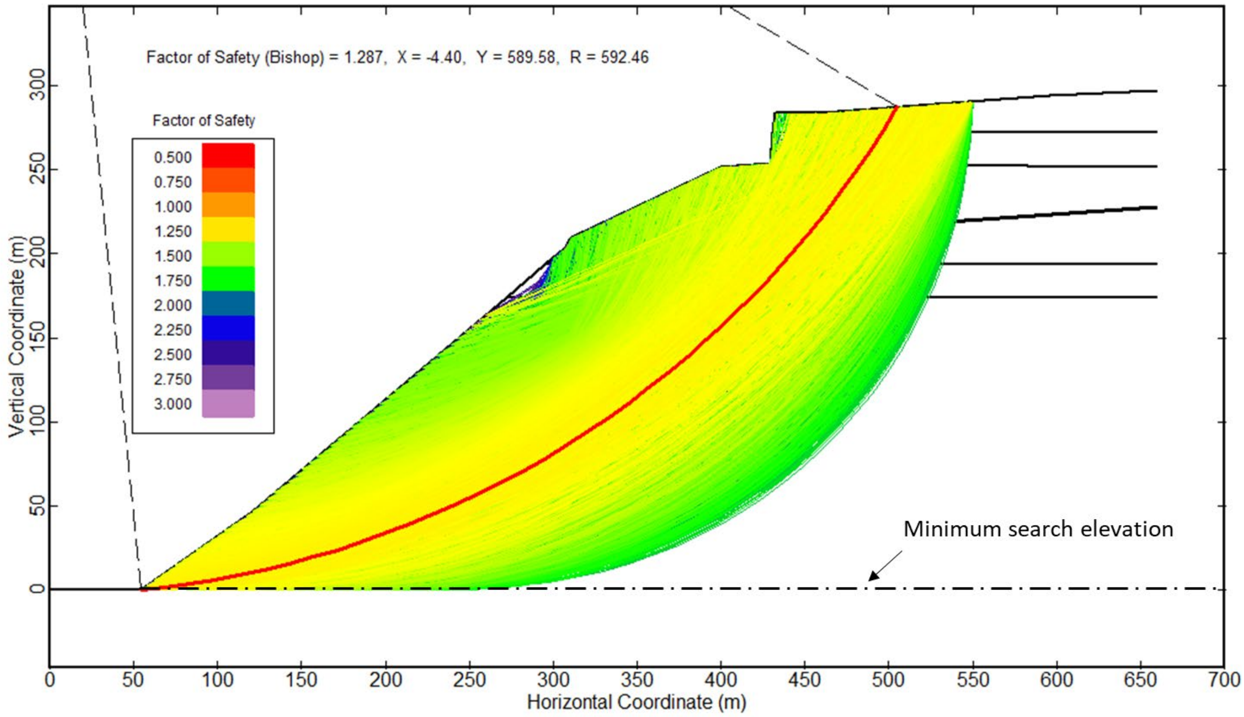


Figure 5.47 The overall stability (F.S. = 1.287) of Example Problem 6.

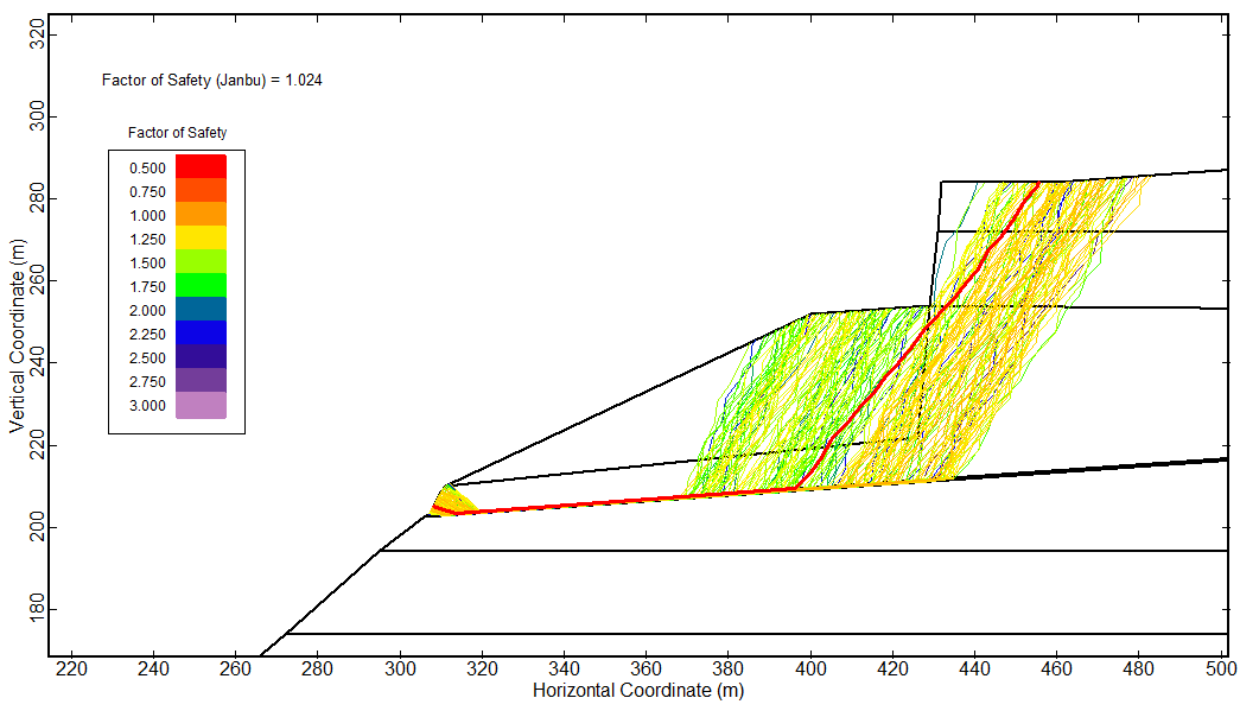


Figure 5.48 The stability of sliding through the weak layer (F.S. = 1.024) of Example Problem 6.

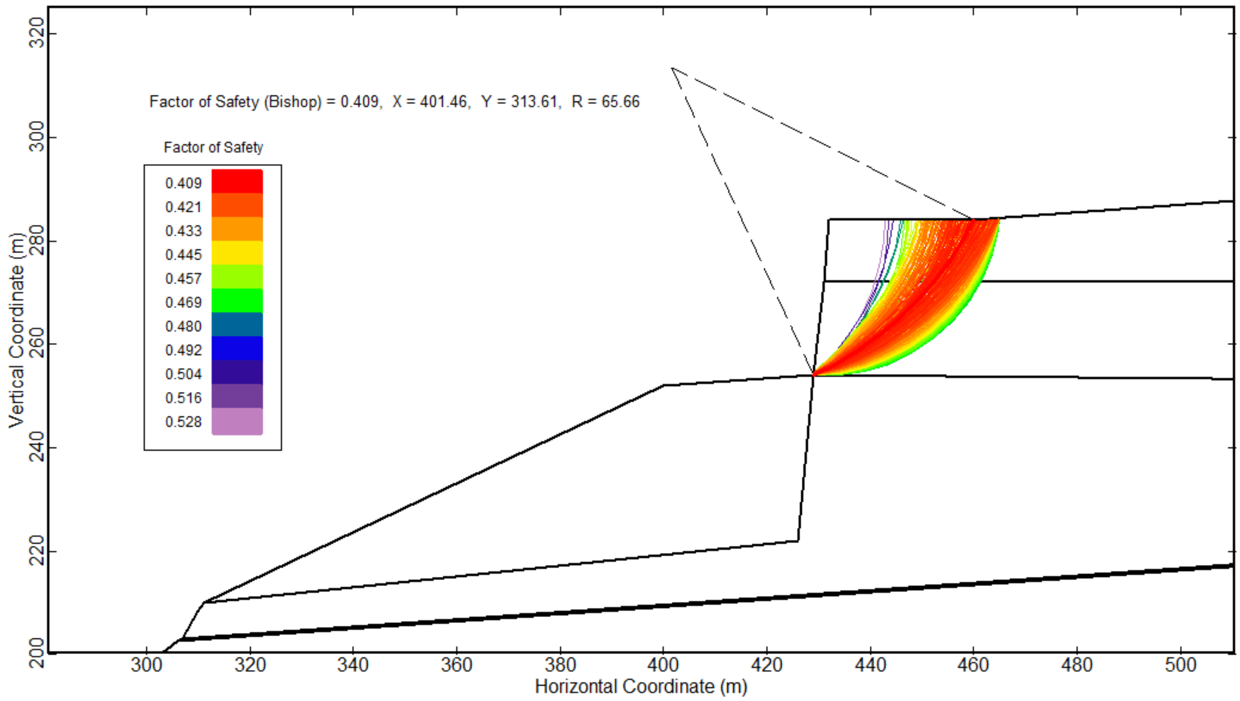


Figure 5.49 The stability of the top two layers (F.S. = 0.409) of Example Problem 6.

5.8 Example Problem 7 (Slope Stabilized with Piles)

5.8.1 Input and Output Data Files for Example 7

The input data files for all examples presented in this manual are installed automatically with the program. The default installation directory of the example files is the following: *(Root Drive) c:\Ensoft\PYwall2025-Examples*.

The input-data filenames for Example 7 are the following:

EnSlope Ex7-NoPile.slpd

EnSlope Ex7-Pile.slpd

The output-data filenames for Example 7 are the following:

EnSlope Ex7-NoPile.slpo

EnSlope Ex7-Pile.slpo

5.8.2 Model Description

This example demonstrates how to model the shear resistance of drilled shafts in a slope stability analysis. A schematic of the slope and the planned location of the dilled shafts is shown in Figure 5.50. The slope is 55 ft tall with a slope angle of 38.2°. The soil profile consists of two layers. The soil on the top layer has a cohesion of 450 psf and a friction angle of 18°. The bottom layer has a cohesion of 1800 psf. The safety factor of the original slope (without drilled shafts) is 1.164, as obtained from limit-equilibrium analyses with Ensoft's EnSlope software using the simplified Bishop method (*EnSlope Ex7-NoPile.slpd)*.

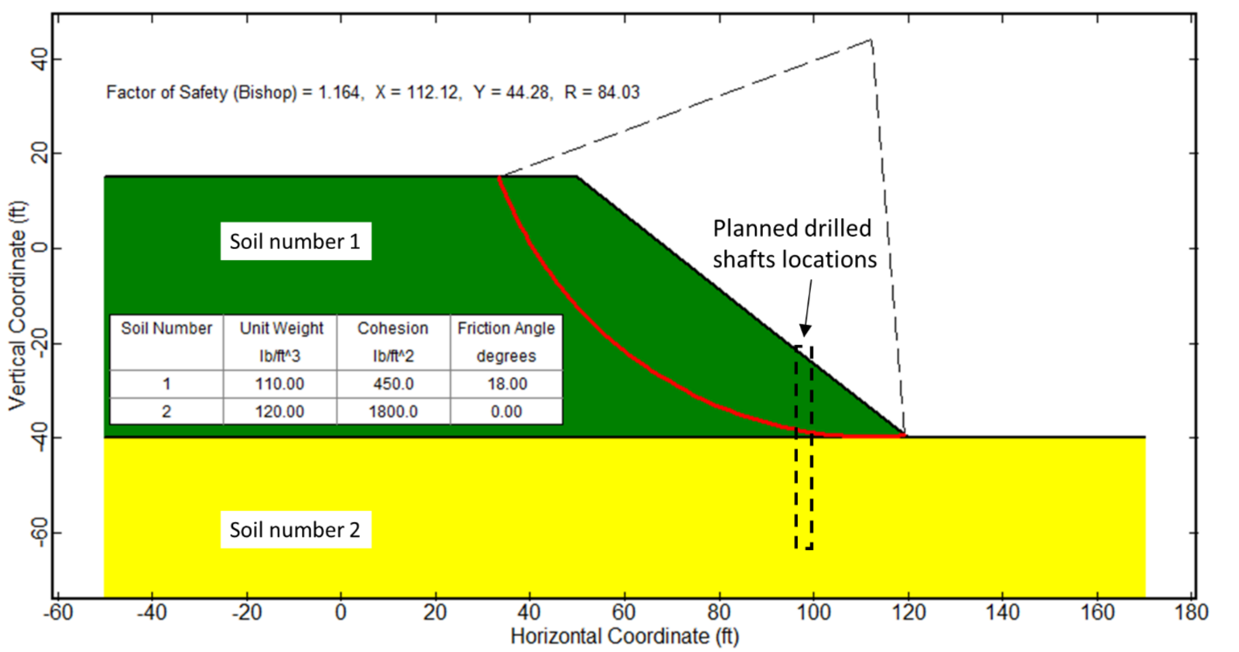


Figure 5.50 Scheme for Installing a Row of Piles in a Slope Subject to Sliding

A row of 40 ft long piles is installed at one-third the height of the slope. The piles are 36-inch diameter drilled shafts with ten #14 reinforcing bars. The reinforcement provides 2.21 percent steel. The nominal moment capacity of each shaft was computed to be 9,553 in-kips. Using a resistance factor of 0.9 for drilled shafts with no axial loading, the ultimate moment capacity is 8,597 in-kips. The center-to-center spacing between drilled shafts is 5 ft. Since the spacing is larger than the pile diameter, soil can flow around the pile. A slope failure can thus occur without the pile reaching a shear failure. Instead of the shear capacity of the pile, the shear demand of the pile associated with a tolerable soil movement (e.g., 4 inches) above the slip surface is a better estimation of the shear resistance for slope stability analyses.

In LPILE, the options for shear-demand calculations are enabled under the 'Data > Options and Settings' menu by checking (1) the 'Use Separate Soil Movement Profiles for Each Load Case' and (2) the 'Compute Pile Shear Demand Along Depth' (see Figure 5.51).

> The 'Use Separate Soil Movement Profiles for Each Load Case' option allows for an arbitrary soil movement profile to be used in the shear-demand calculation. Results from this option are obtained from one soil movement profile for each loading case and are presented in the LPILE program.
>
> The 'Compute Pile Shear Demand Along Depth' option computes shear demands at multiple slip-surface locations along the pile for a *step-type* soil movement profile. Results from this option are obtained from the 'Graphics > Shear Demand vs. Depth' menu and are also tabulated in the output file. The shear demands at various depths saved in the LPILE output file can be imported into Ensoft's EnSlope software and used as pile shear resistance in the slope stability analyses.

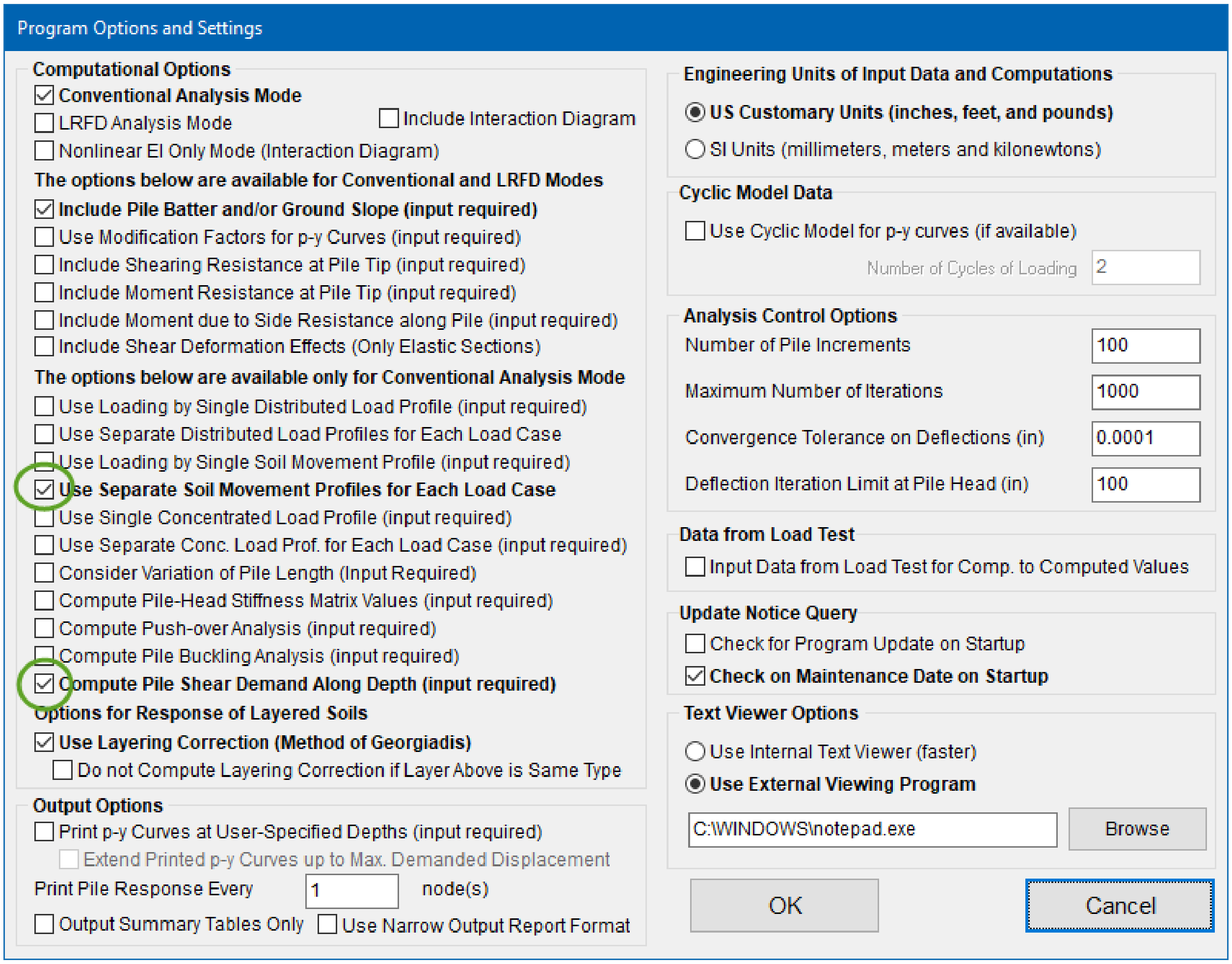


Figure 5.51 Shear-Demand Options & Settings in LPILE

5.8.3 Use Separate Soil Movement Profiles for Each Load Case

With this option, users can define various lateral soil movements along the pile (Data > Lateral Soil Movement). LPILE calculates the resulting lateral displacement, shear, and moment profiles from the assigned soil movement profile. For limit equilibrium analyses, a step profile is often assumed with a constant soil movement (e.g., 4 inches) above the slip surface and zero soil movement below the slip surface. However, other linear or nonlinear soil movement profiles can also be analyzed. As an example, Figure 5.52 shows the results from 4-inch soil movements above a slip surface at 19.5 ft below the ground surface. The resulting shear demand is 54.0 kips. As shown in the figure, the deflection at the top of the pile is close to 5 inches. This is greater than the soil movement. Consequently, the mobilized soil reaction is negative in the top 6.5 ft. A stiffer and longer pile with less deformation can increase soil resistance. It is also interesting to see that the maximum moment occurs at 27.2 ft below the ground surface, which is about 7 ft below the slip surface. The maximum moment of 5,997 in-kips is below the ultimate pile capacity of 8,597 in-kips.

This option is ideal for analyzing a specified slip surface. If the exact depth of the critical slip surface is unknown, the method in the next section (compute pile shear demand along depth) can be used to search for the critical slip surface.

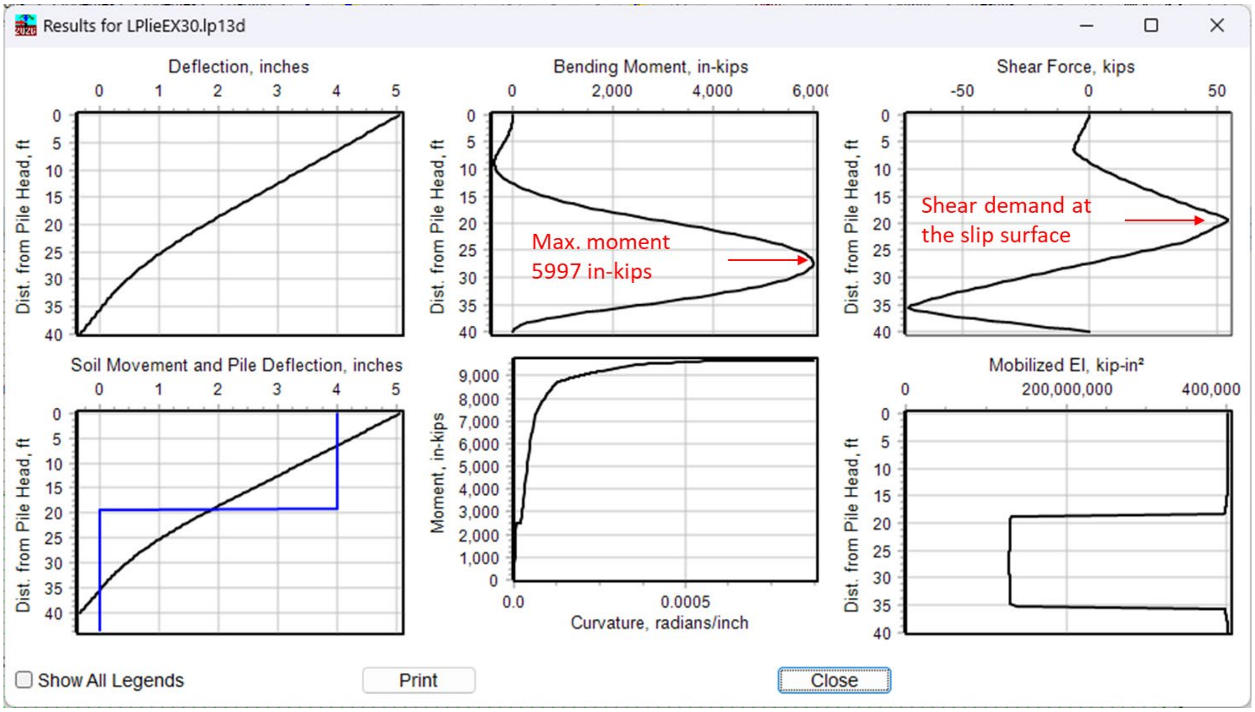


Figure 5.52 Results from 4-inch Soil Movement above a Slip Surface19.5 ft below Ground

5.8.4 Compute Pile Shear Demand Along Depth

With this option, LPILE calculates shear demands along the pile (Data > Control for Computation of Shear Demand along Pile). Users can define the soil movements both above and below a slip surface. Only a step soil-movement profile is available in this option. Soil above the slip surface is assumed to move as a block with a uniform lateral displacement. In most cases, soil movements below the slip surface are assumed to be zero. In the example settings shown in Figure 5.53, slip surfaces are assigned at 20 locations. At each location, the soil movement above the slip surface is assumed to be 4 inches. Shear demands are calculated separately for each location. The outputs are presented in the Graphics > Shear Demand vs. Depth dialog (Figure 5.54) and a tabulated output is saved at the end of the output file (Figure 5.55) (Computation > View Output Text File).

The resulting shear at each section divided by the pile spacing can be imported into Ensoft's EnSlope (Figure 5.57) as shear resistance when modeling piles as reinforcements. To import into EnSlope, the user must build a slope model (or open one already made, such as *EnSlope Ex7-NoPile.slpd* that is installed with EnSlope) and select Data > Reinforcement Layers (optional) (Figure 5.56) to add a pile as reinforcement. Subsequently, the user should click the button Import from LPILE and then Browse and Open to navigate to the LPILE output data file (for this example, the *Example 28 Shear Demand for Slope Stability\Example 28 Shear Demand for Slope Stability.lp13o* file installed with LPILE). In the resulting screen, shown in Figure 5.57, the user should enter the following parameters:

X Coord — for the X coordinate of the pile location (= 95 ft for this example)

Y Coord — for the Y coordinate of the pile location (= -21.4 ft for this example)

Pile Spacing — to indicate the separation between drilled shafts (= 5 ft for this example)

Multiplication Factor in case any multiplication is necessary (=1 for this example)

In this example, the resulting safety factor for the drilled shafts is 1.312, as compared to 1.164 of the original slope without piles, based on the simplified Bishop method (Figure 5.58).

6.1.1 Other Considerations

The maximum moment in the pile is saved in the LPILE output file. As shown in the table of Figure 5.55, the maximum moment of 6,749 in-kips occurs when the slip surface is located at a depth of 11.26 ft. The maximum moment of 6,749 in-kips is below the ultimate capacity of 8,597 in-kips. The resulting moment at each section is also saved in the LPILE output file. The magnitude of the moment at each section is generally greater than zero, indicating that the resulting shear demands acts predominantly above the slip surface. For moment-based limit equilibrium analyses, assuming that the shear demand acts on the slip surface may result in a higher safety factor. As shown in Figure 5.58, the critical slip surface is located near the bottom of the top soil layer, approximately 19.5 ft below the slope surface. Dividing the bending moment at section by the shear force at section yields a distance of 6.17 ft (= 3384444/45710.78/12, Figure 5.55), which is approximately 7% of the radius of the critical slip surface (88.11 ft). Users can reanalyze the slope stability by reimporting the shear demand from LPILE and entering a multiplication factor of 0.93 in EnSlope. The resulting factor of safety would be reduced to 1.301.

In this example, only soil movement perpendicular to the pile axis is considered and soil movements above the slip surface are assumed to be uniform. For a circular slip surface, soil movements may increase with increasing distance from the center of the slip surface and often include components that are both perpendicular and parallel to the pile. Engineers can select the 'Use Separate Soil Movement Profiles for Each Load Case' option in LPILE to evaluate the effects of different soil movement profiles. For movements parallel to the pile axis, "*t-z*" analyses may be performed to determine the pile resistances that are mobilized by soil movement in the axial direction (using the TZPILE software from Ensoft). In most cases, pile axial resistance exceeds lateral resistance. Consequently, safety factors derived by considering only soil movements perpendicular to the pile are likely to be conservative compared with those obtained by considering soil movements in both the perpendicular and parallel directions.

The 4 inches of soil movement selected in this example is intended to simulate the ultimate capacity. In some applications, 4 inches of soil movement may be excessive. Engineers may select a smaller value that is more appropriate for the specific application.

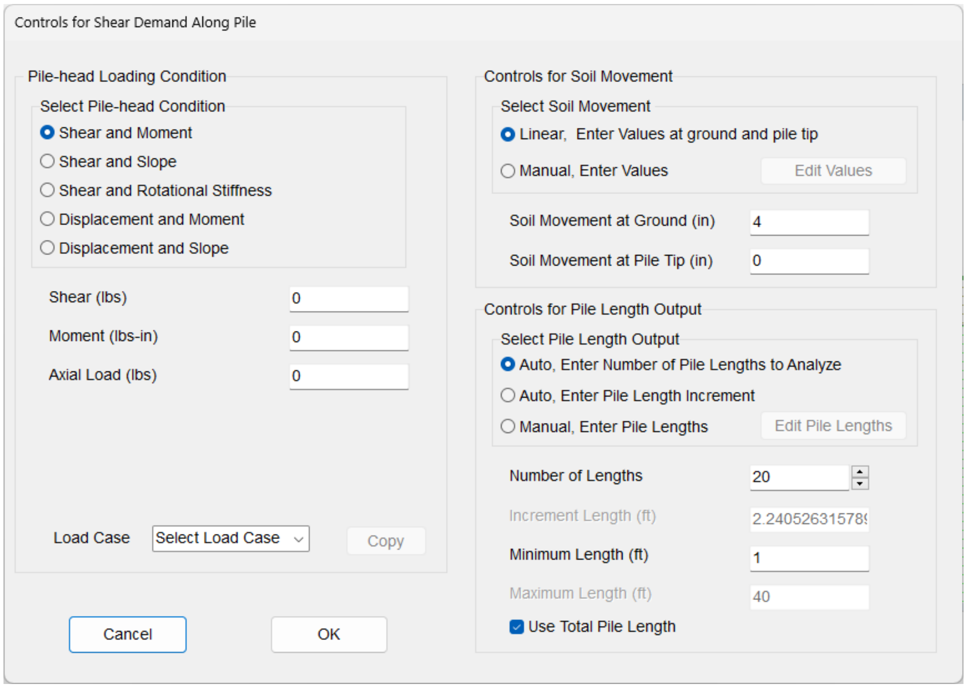


Figure 5.53 Sample Controls for Shear Demand Along Pile

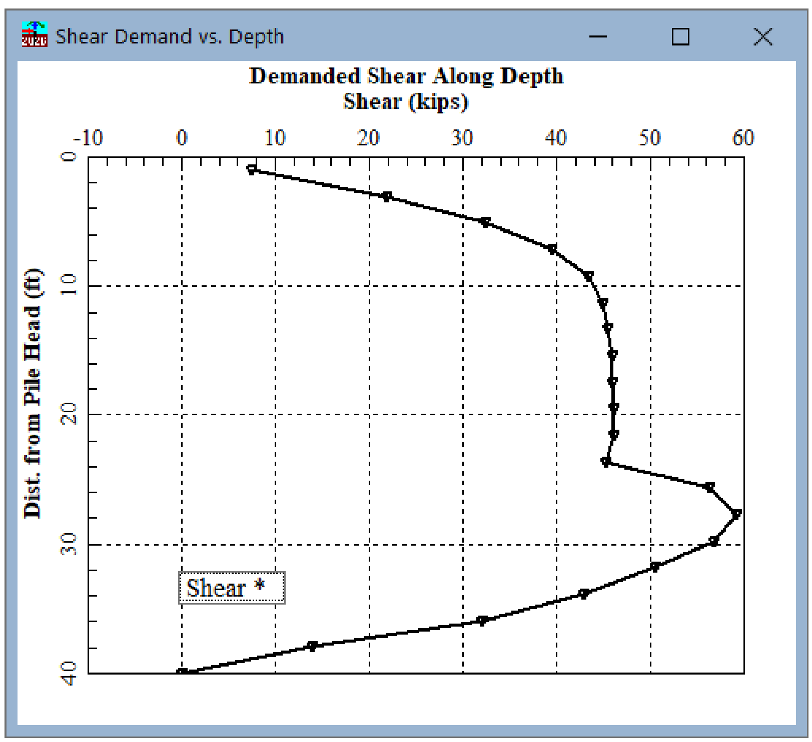
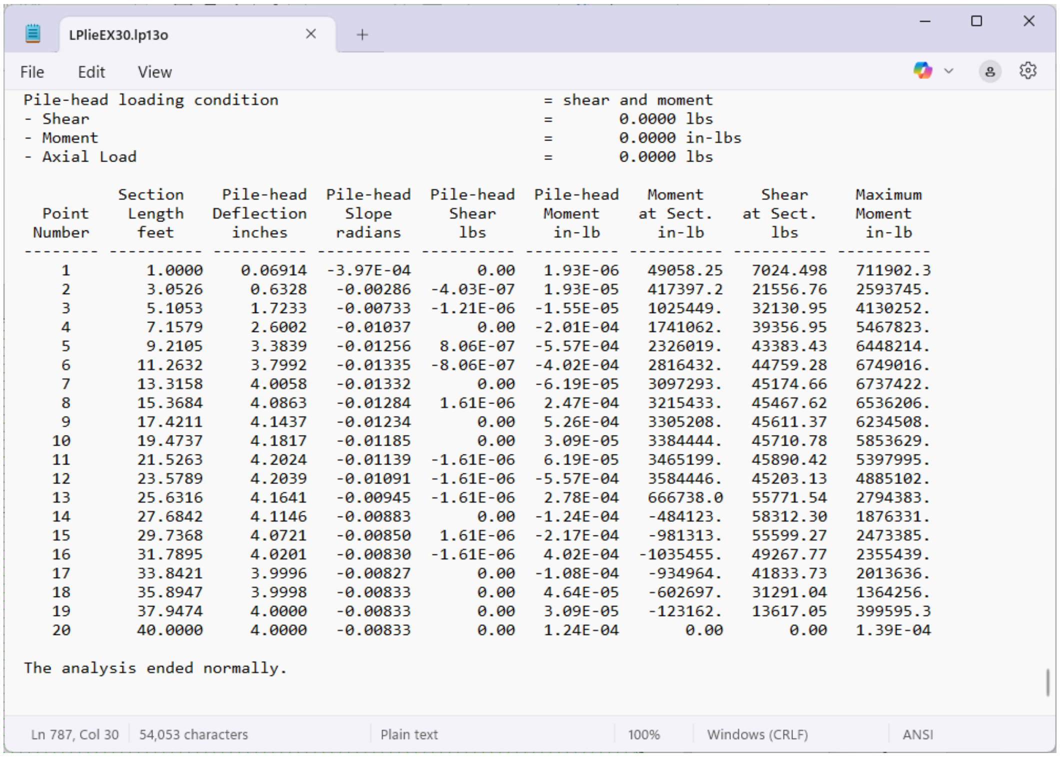


Figure 5.54 Sample Shear Demand vs. Depth Plot



Pile-head loading condition = shear and moment
- Shear = 0.0000 lbs
- Moment = 0.0000 in-lbs
- Axial Load = 0.0000 lbs

Point Number	Section Length feet	Pile-head Deflection inches	Pile-head Slope radians	Pile-head Shear lbs	Pile-head Moment in-lb	Moment at Sect. in-lb	Shear at Sect. lbs	Maximum Moment in-lb
1	1.0000	0.06914	-3.97E-04	0.00	1.93E-06	49058.25	7024.498	711902.3
2	3.0526	0.6328	-0.00286	-4.03E-07	1.93E-05	417397.2	21556.76	2593745.
3	5.1053	1.7233	-0.00733	-1.21E-06	-1.55E-05	1025449.	32130.95	4130252.
4	7.1579	2.6002	-0.01037	0.00	-2.01E-04	1741062.	39356.95	5467823.
5	9.2105	3.3839	-0.01256	8.06E-07	-5.57E-04	2326019.	43383.43	6448214.
6	11.2632	3.7992	-0.01335	-8.06E-07	-4.02E-04	2816432.	44759.28	6749016.
7	13.3158	4.0058	-0.01332	0.00	-6.19E-05	3097293.	45174.66	6737422.
8	15.3684	4.0863	-0.01284	1.61E-06	2.47E-04	3215433.	45467.62	6536206.
9	17.4211	4.1437	-0.01234	0.00	5.26E-04	3305208.	45611.37	6234508.
10	19.4737	4.1817	-0.01185	0.00	3.09E-05	3384444.	45710.78	5853629.
11	21.5263	4.2024	-0.01139	-1.61E-06	6.19E-05	3465199.	45890.42	5397995.
12	23.5789	4.2039	-0.01091	-1.61E-06	-5.57E-04	3584446.	45203.13	4885102.
13	25.6316	4.1641	-0.00945	-1.61E-06	2.78E-04	666738.0	55771.54	2794383.
14	27.6842	4.1146	-0.00883	0.00	-1.24E-04	-484123.	58312.30	1876331.
15	29.7368	4.0721	-0.00850	1.61E-06	-2.17E-04	-981313.	55599.27	2473385.
16	31.7895	4.0201	-0.00830	-1.61E-06	4.02E-04	-1035455.	49267.77	2355439.
17	33.8421	3.9996	-0.00827	0.00	-1.08E-04	-934964.	41833.73	2013636.
18	35.8947	3.9998	-0.00833	0.00	4.64E-05	-602697.	31291.04	1364256.
19	37.9474	4.0000	-0.00833	0.00	3.09E-05	-123162.	13617.05	399595.3
20	40.0000	4.0000	-0.00833	0.00	1.24E-04	0.00	0.00	1.39E-04

The analysis ended normally.

Figure 5.55 Sample Tabulated Output from Compute Pile Shear Demand Along Depth

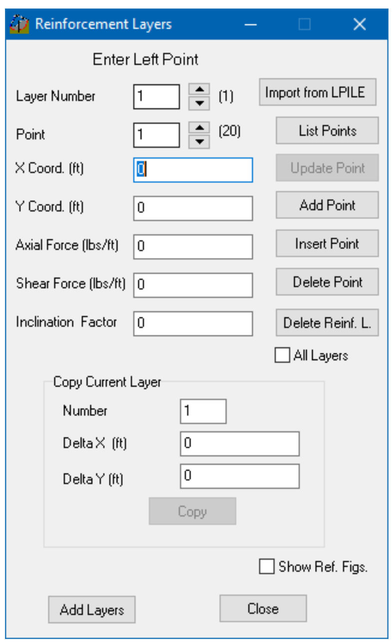


Figure 5.56 'Data > Reinforcement Layers' dialog in EnSlope

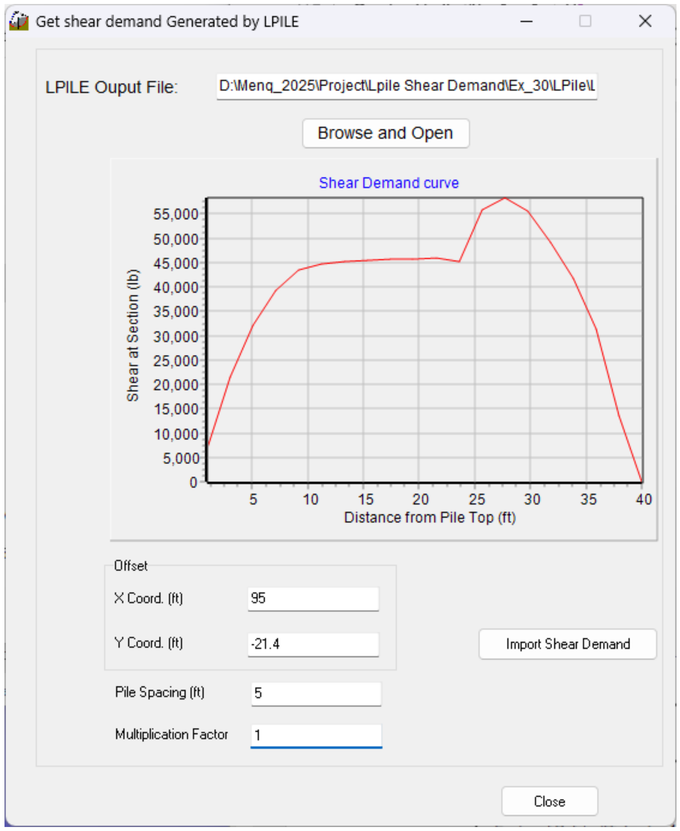
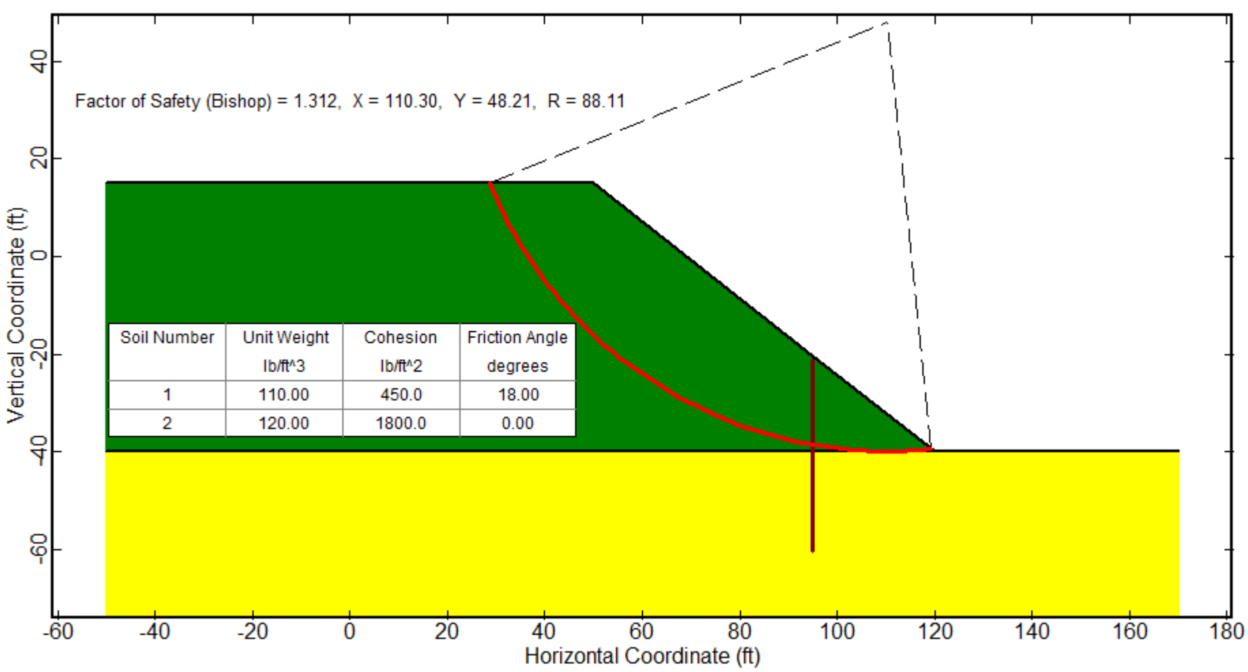


Figure 5.57 Sample Import Shear Demand Dialog from LPILE Output File in EnSlope



Soil Number	Unit Weight lb/ft^3	Cohesion lb/ft^2	Friction Angle degrees
1	110.00	450.0	18.00
2	120.00	1800.0	0.00

Figure 5.58 Limit Equilibrium Analyses with a Row of 5-ft-Spaced Drilled Shafts

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