

# **STABLPRO 2015 – User's Manual**

## **A Program for Slope Stability Analysis**

by

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# **CHAPTER 1. Introduction**

## 1.1 General Description

Program STABLPRO has been developed specifically for users to enter input data and to view output graphics in the Microsoft Windows platform. The STABL programs (including STABL4, STABL4M, STABL5 and STABL5M) have been well accepted as useful tools for analyzing the stability of slopes. However, the series adopts a command-line format for data entry which may be inconvenient to infrequent users. Program STABLPRO enhances STABL program, a publicly available program through Federal Highway Administration, with new computation functions, user-friendly features for data entries, and graphics presentation of output results.

The current version - STABLPRO was written under the Microsoft Windows platform and uses the 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 changed freely 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.

The current version of STABLPRO allows the user to analyze a reinforced-earth slope. It also allows either English units (ft and lbs) or S.I. units (meter and kN) for computation. The program will also help the user with unit conversions if the user has to change from one unit system to the other unit system. The corresponded unit systems will be printed in the output file accordingly.

## 1.2 Background of the Program

Program STABL is a computer program written for the general solution of slope-stability problems by a two-dimensional, limiting- equilibrium method. The original program of STABL was developed by Ronald A. Siegel at Purdue University in 1975. STABL was placed on line for routine use in 1976 by the Indiana Department of Highways, and after being reported in the open literature, the program began to be adopted by many agencies.

However, due to more extensive use of STABL for teaching purposes, and also at the request of users, STABL has been modified several times since it was introduced in 1975. The versions that are recommended by Federal Highway Administration are STABL4, STABL4M, STABL5 and STABL5M. STABL4 was developed by J. R. Carpenter in 1984 to handle tieback loading. STABL5 differs from STABL4 in that STABL5 includes the Spencer method of analysis. J. E. Thomaz and J. R. Verduin further modified STABL5 to introduce the Janbu coefficient and pore-pressure modifications in STABL5M.

## 1.3 Features of the Program

Program STABLPRO was developed to improve the user-friendly features for Program STABL. STABLPRO was written for Windows XP/Vista/7/8 platforms and uses a graphics interface for data entry. The user may read the screen information, 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.

STABLPRO integrates the input modules, main-computation module, and graphics module into one system. Therefore, the user may freely call on each module inside Windows for operation. In general, after entering the input data, the user may use the computation module to execute the input data.

The user may also call on the graphics module 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.

Program STABL features unique random techniques for generation of potential failure surfaces for subsequent determination of the most critical surfaces and their corresponding factors of safety. One technique generates circular failure surface, another technique generates general, irregular surfaces of random shape. While the latest versions of the STABL group of programs are more versatile than the earlier versions, all of the versions of Program STABL adopt the original command-line type of input format which is inconvenient to infrequent users.

The extensive use of STABL for academic purposes generated requests from users to introduce many improvements to the original STABL program since its introduction. The current version of STABLPPO can handle tieback loading, reinforced-earth layers in embankment, and Spencer’s method of analysis.

## 1.4 History of Development

### 1.4.1 STABLPPO1 (1995)

With the advent of wide-spread availability of personal computers, the founder of ENSOFT, Inc., had a vision to improve the engineering capability for analysis and design of deep foundations by providing useful software tools. The development of STABLPPO1 was completed under the direction of Dr. Lymon C. Reese and was first commercially distributed in 1987. While based on an earlier mainframe program, STABLPPO1 was developed to use an interactive input method.

### 1.4.2 STABLPPO, Version 1 (1995)

STABLPPO 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 STABLPPO utilized Windows-based pre- and post-processors, while retaining the original computing engine from STABL4M.

### 1.4.3 STABLPPO, Version 2 (1998)

This version of STABLPPO 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.

### 1.4.4 STABLPPO, Version 3 (2004)

This version of STABLPPO 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 File Menu for users to load or retrieve quickly and conveniently.

STABLPPO Version 3 add 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.

### 1.4.5 STABLPRO 2015, Version 4 (2015)

Program STABLPRO uses the year number as the version sequence starting in 2015, while keeping the second number of the release equal to the input data format (input data format 4). The major improvements in v2015.4 were a complete rewrite for a more intuitive interface under Windows 8 environment.

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

## 1.5 Organization of STABLPRO Manuals

The documentation provided with the computer program STABLPRO 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 program STABLPRO. The Technical Manual is distributed in protected form that can only be opened by licensed users of the STABLPRO program.

Both Manuals are installed with the STABLPRO program and accessible via any one of the following three methods: i) from the Windows Start Menu, ii) from the Ensoft tile in Windows 8, or iii) from the Help menu within the STABLPRO program.

## 1.6 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" ; "Ctrl+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](mailto:support@ensoftinc.com)

## 1.7 Contents of the STABLPRO Package

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

- One USB device (sometimes known as hardware key or dongle),
- one backup CD-ROM (this may be missing in future releases, since the full program is available for free downloading from the [www.ensoftinc.com](http://www.ensoftinc.com) website).

The user-selected installation directory (default directory is *Program Files\Ensoft\STABLPRO2015*) contains the main Windows-program module (*winSTABLPRO2015.exe*), the program engine for direct computations (*STABLPRO2015\_DLL.dll*), the Help file (*STABLPRO\_2015.chm*), and other support files. The User's and Technical Manuals are also included in the installation directory. Several examples of input files (all files with extension *\*.sl4d*) are installed in a separate *Ensoft/STABLPRO2015-Examples* subdirectory in the root Windows drive (usually *c:\*).

## 1.8 Hardware Requirements

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

- Any personal computer with an Intel® Pentium® or newer processor.
- A hard disk with at least 20 MB of free space.
- Microsoft Windows® 2000, XP, VISTA or Windows 7/8. A newer release of the Microsoft Windows® operating system may need a more recent update of the STABLPRO software.
- Minimum of 2 GB of free RAM memory.
- A mouse or similar pointing device.
- Optional: Any windows-compatible printer.

## 1.9 Technical Support

Although computer program STABLPRO was designed to be distinguished by its ease of use and by its helpful User's Manual, some users may still have questions. The technical staff at ENSOFT strongly supports all registered users with questions related to the installation or use of STABLPRO, 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](mailto:support@ensoftinc.com)
- Fax to: (512) 244-6067
- Telephone call to: (512) 244-6464, extension 2

Users are strongly encouraged to utilize electronic means of support via email. In any event, users should include the following information when requesting for software support: software version (obtain from the Help/About menu), description of the problem copy, input-data file attachment, contact person and licensed company or user name (or name and office location of the licensed company).

Although immediate answers (less than two hours during regular working hours) are offered on most technical support requests, up to two business days should be expected in case of difficulties or conflict of schedules. The users will be informed of ENSOFT's reception of their electronic mails requesting software support if the problem is complicated and cannot be resolved within two business days.

### **1.9.2 Support by Telephone**

Technical help by means of 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 that have a current annual maintenance policy.

### **1.9.3 Upgrade Verification and Internet Site**

Starting from STABLPRO v2015 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 downloading.

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

### **1.9.4 Changes of 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

Program STABLPPO is distributed with an associated USB key (hardware key or dongle). The hardware 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). This method of software protection has been found to provide compatibility with existing operating systems, better stability than other alternatives, and allows users to obtain software updates or replacements via downloads from the internet.

### 2.1.1 Installation of Single-User Version

This version of STABLPPO has been tested to be compatible with the following versions of the Microsoft Windows® operating systems: 2000, XP, Vista, Windows 7, 8 and 8.1.

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

1. Plug the supplied hardware lock (USB device) into one of the available USB ports in your computer. The USB device is plug-and-play compatible so the operating system will recognize the USB device automatically and a small solid green light should be noticeable 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 CD-ROM and the main installation program does not start automatically upon insertion of the CD 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 CD. 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.
3. If the user installs from a downloaded file then please run the downloaded file (double click) and go to instruction #5.
4. Click anywhere on the STABLPPO 2015 icon and then click on the **Install Standard** button to start the installation of STABLPPO.
5. The user should read the license agreement shown in Figure 2.2. Please click **Yes** if you agree and would like to proceed.
6. Select **Single-User License** in Figure 2.3 then click **Next**. For network installations please contact Ensoft support ([support@ensoftinc.com](mailto:support@ensoftinc.com)).
7. The user will be provided with an option to select a drive and directory for the installation of STABLPPO (see Figure 2.4); the default is *c:\Program Files (x86)\Ensoft\STABLPPO2015*. If the desired directory does not exist, the installation program will automatically create a new directory in the chosen hard drive.

Most distribution files will be copied to the installation directory (either the default or the one selected by the user). However, certain files are copied to system directories in Windows and some Windows services are started during installation (mainly for Network installations). The name of the system files, their exact locations, and the type of services that are started may change in time and for different versions of the Microsoft Windows® operating system.



Example files are copied to the following subdirectory under the root Windows drive:

*(Root Drive)\Ensoft\STABLPRO2015-Examples*

8. During the installation the user will be asked to set the file extension association for opening STABLPRO 2015 input data files (see Figure 2.5). If the user agrees (leaves the default check mark) then double clicking (or running) any input data file with extensions of the type *filename.sl4d* will start the installed STABLPRO 2015 software.
9. The user will be prompted to confirm the shortcut directory name that will be created in the Windows Start Menu (See Figure 2.6). The default is *Start Menu/Programs/Ensoft/STABLPRO2015*. Windows 8 will automatically create an Ensoft tile with the same shortcuts.



Figure 2.1 Main CD-ROM installation screen for ENSOFT software (may change with time)

After the installation is finished, it is not necessary to reboot Windows for the program to run. The user may run the program by selecting STABLPRO v2015 from the standard links installed in the Microsoft Windows® Start Menu: Start Menu > All Programs > Ensoft > STABLPRO2015



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

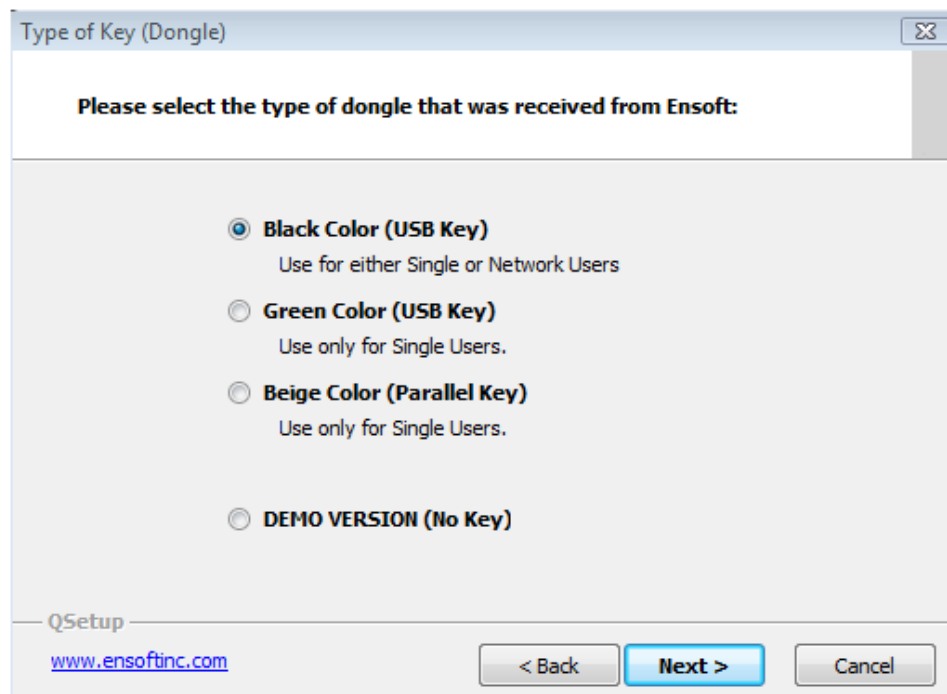


Figure 2.3 Selection of Single-User License (may change with time)

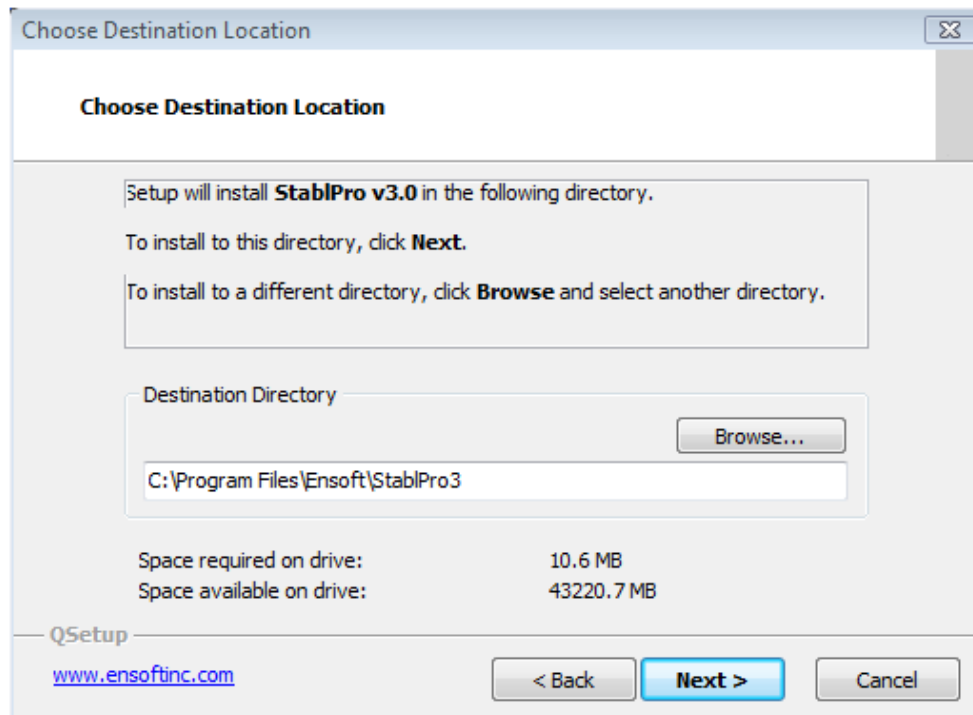


Figure 2.4 Default Installation Directory for Program Files (may change with time)



Figure 2.5 File Extension Association for STABLPRO 2015 Data Files (may change with time)

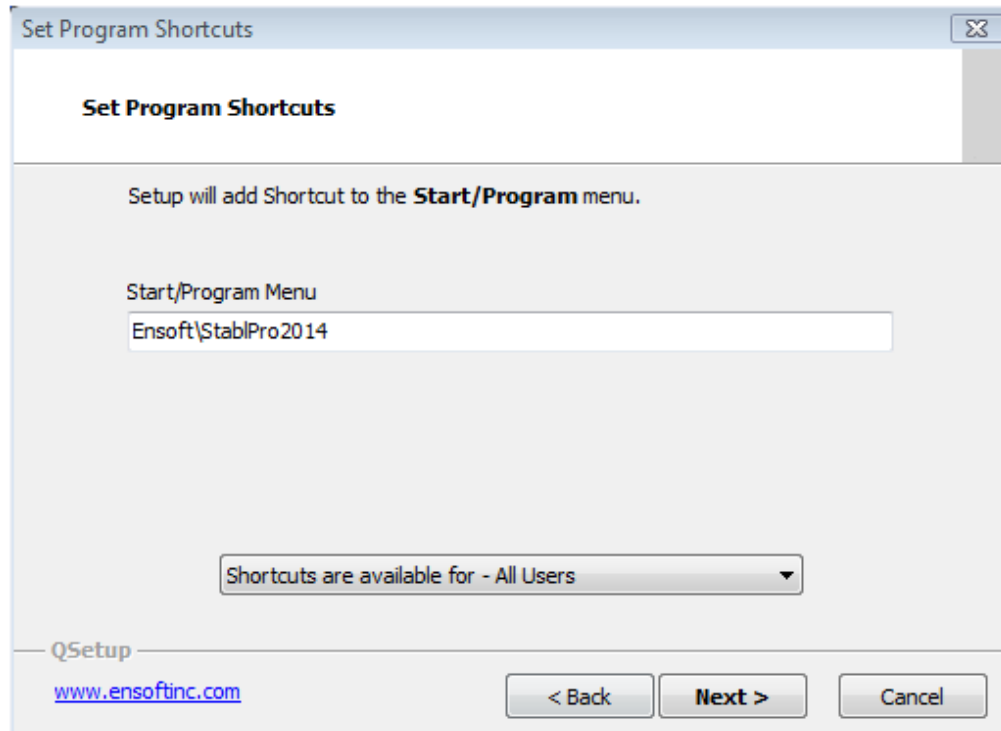


Figure 2.6 Default Shortcut Folder in Windows Start Menu (may change with time)

### 2.1.2 Introduction of Network Version

Special network licenses and USB hardware keys (network keys) are available for users who desire to operate STABLPRO on a Windows network. The network version is limited to users with two or more licenses at the same physical site. Discounted rates apply for users purchasing multiple licenses for the same site.

Network versions of STABLPRO have special subroutines written for installations in “software servers” and for installations of “individual clients”. The “software server” or “license server” is the computer that will be carrying the network USB key provided by ENSOFT, INC. The software server is not necessarily the same as the existing network server. Any computer in the existing Windows network may be designated software server for STABLPRO 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 is installed on its local drive. Software “clients” may be all computers of the licensed site that have the program installed as client. Software clients do not need any hardware key attached to their computers. The program installed in software clients will be allowed to run if their IP are within the allowable (licensed) IP ranges and if the computer designated as software server is accessible on the network with the proper operating system and with its network key secured in place.

Users of the network version of STABLPRO are allowed to have the software installed in as many computers as desired within the licensed IP ranges of their local Windows network. However, only a number of users equal to the total number of purchased licenses will be able to operate the program at the same time.

### **2.1.2.1 *Installation of Network Version***

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:

<http://www.ensoftinc.com/updates/Ensoft Network Installation Notes.pdf>

Alternatively, the document can be requested via email to [support@ensoftinc.com](mailto:support@ensoftinc.com)

### **2.1.2.2 *Silent Installations on Client Computers***

For installation of network licenses on local client computers there is an option for command-based installations that are completely silent (performed without other user input). Instructions for silent installations on client computers can be downloaded from the Ensoft web site using the following link:

<http://www.ensoftinc.com/updates/Silent Install on Client Computers.pdf>

Alternatively, the document can be requested via email to [support@ensoftinc.com](mailto:support@ensoftinc.com)

### **2.1.3 *Backup of Original Software***

The distributed software may be copied for backup purposes. The program may be installed in several computers at the same time. However, unless network licenses are purchased, the program will only operate in computers that carry the appropriate hardware key.

### **2.1.4 *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 STABLPRO menu. Software users may freely download the latest program update from the following site: <http://www.ensoftinc.com>

## **2.2 *Getting Started***

A general diagram showing the menu choices and operational flow chart of program STABLPRO is presented in Figure 2.7. The following paragraphs provide a short description of the operational features of STABLPRO and should quickly enable the user to get started with the program.

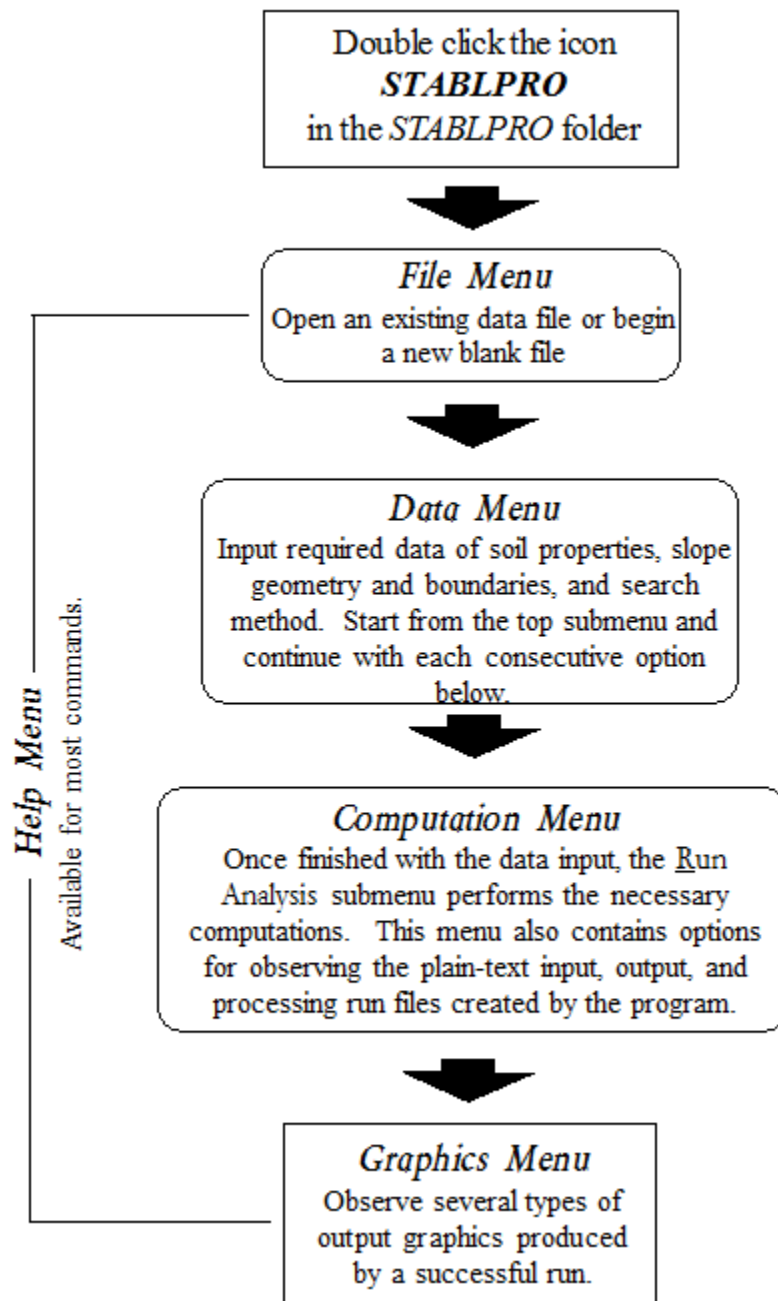


Figure 2.7 Sample organization and operational flow chart

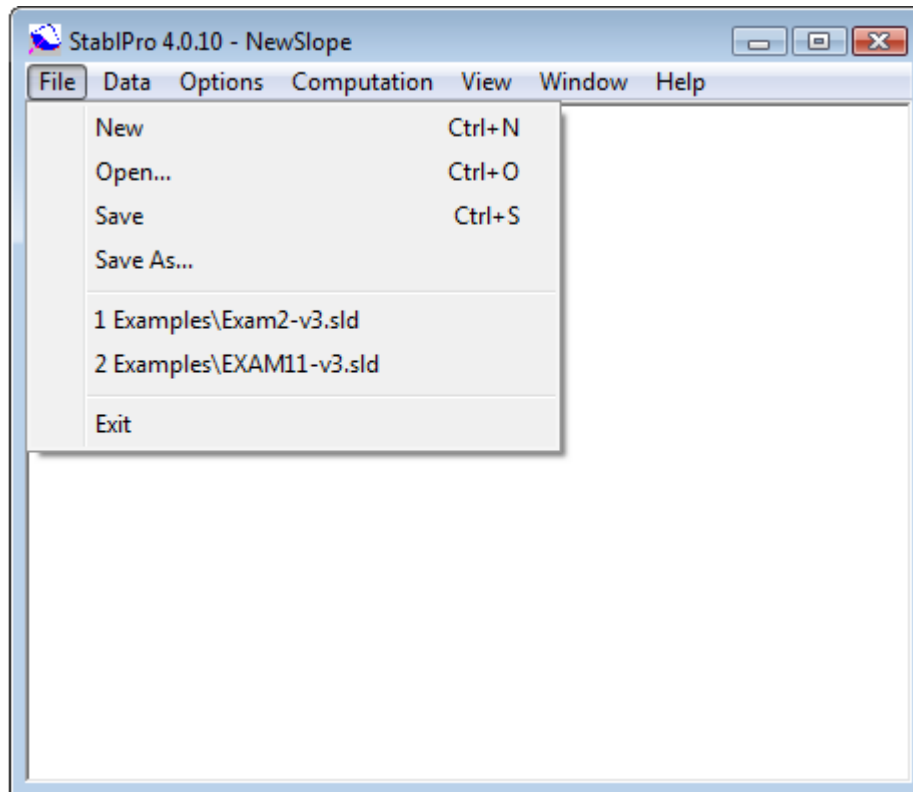
### 2.2.1 Starting the Program

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

### 2.2.2 File Management

The File menu option contains five submenus, as shown in Figure 2.8; 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 STABLPRO.
- Other entries include quick access to a history of recently-opened files.



**Figure 2.8 Options contained in the File menu**

Several additional files are created in every new STABLPRO run. A general description of these files is presented in Table 2.1. Every run of STABLPRO thus 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
*.sl4d	Input-data file	Text file	<i>example1.sl4d</i> <i>example2.sl4d</i>
*.sl4o	Output-data file	Text file	<i>example1.sl4o</i> <i>example2.sl4o</i>
*.sl4p	Plot-data file	Text file	<i>example1.sl4p</i> <i>example2.sl4p</i>
*.sl4r	Processor-data file	Text file	<i>example1.sl4r</i> <i>example2.sl4r</i>

**Table 2.1 Files created in STABLPRO runs**

### 2.2.3 Data Menu

The **Data** menu contains several choices of submenus, as shown in Figure 2.9. The choices are listed below, along with a general description of their use.

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

**Slope Boundary** ..... the total number of boundary lines and the boundary lines used to define the surface boundaries may be entered. The entry will also define the coordinates of each profile line for the geometry of the slope and the soil strata..

**Soil Properties** .. ..... 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.

**Loading** .....this submenu is used to input the data for two loading: surface loads and earthquake loads. This is an optional input.

**Water Surface** ..... this submenu is used to input data for the piezometric surface. This is an optional input.

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

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

**Reinforced Earth Layers** .....Program STABLPRO v3 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 force, and the direction in which the force acts.

**Failure Surface Search** .....the submenu under this menu are as follows: *Specified Failure Surface* allows the user to specify the predefined or a given failure surface;,. *Circular*



*Search (Janbu Method)* allows the use of Janbu's procedures to search for the circular failure surface; *Circular Search (Bishop Method)* allows the use of Bishop's procedures to search for the circular failure surface; *Irregular Surface Search* allows the use of Janbu's procedures to search for the irregular failure surface; *Block Surface Search* allows the use of Janbu's procedures to search for the block failure surface; and *Circular Search (Spencer Method)* allows the use of Spencer's procedures to search for the circular failure surface.

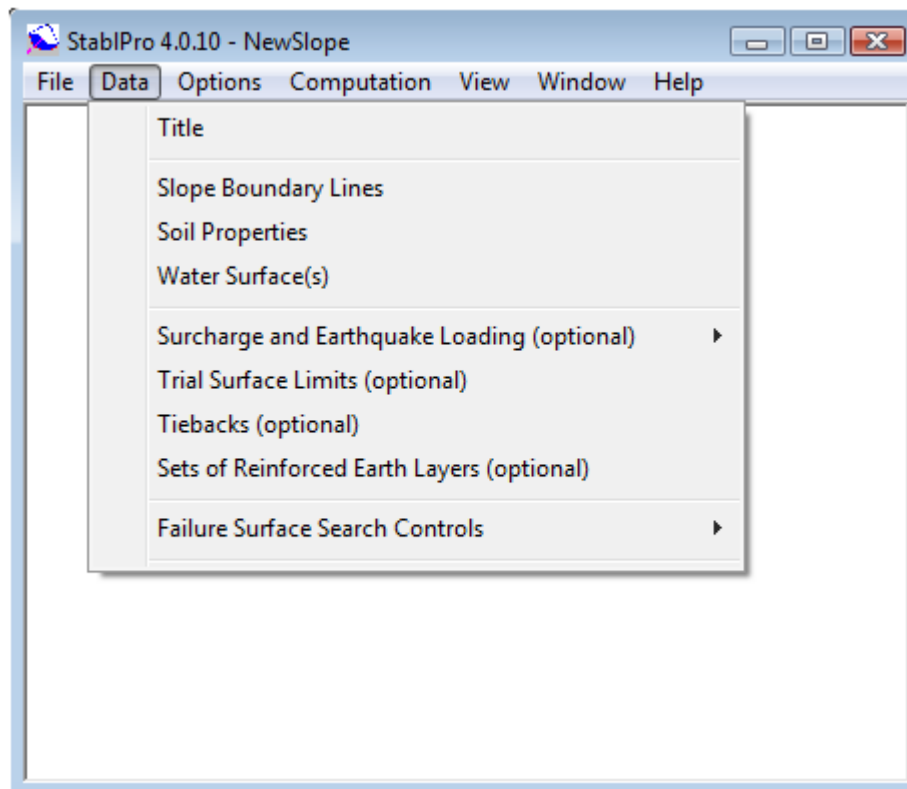


Figure 2.9 Options contained in the Data menu

### 2.2.4 Options Menu

The Options menu is provided for the control of program variables and preferences. The listing of menu options is shown in Figure 2.10 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 the length of each computation increment and also how often to print results. The observation of text files associated with STABLPRO (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.

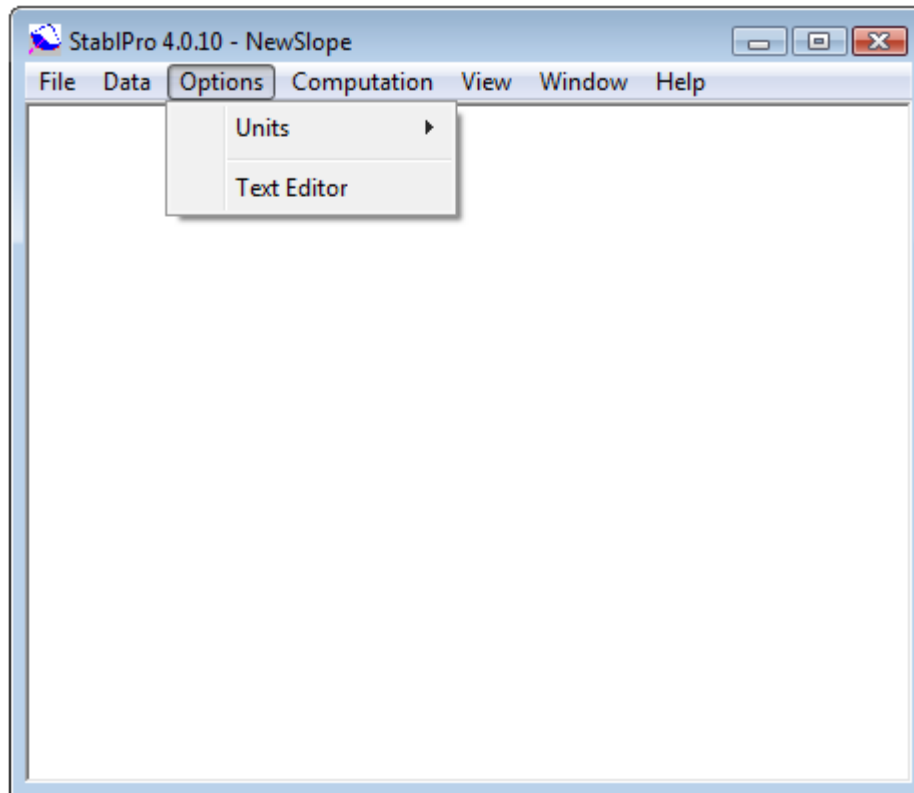


Figure 2.10 Options contained in the Program-Control Options menu

### 2.2.5 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 2.11, 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.

**Edit Input Text .....**this option calls the chosen Text Editor (selected under Options/Text Editor) to observe and/or edit 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.

**Edit 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.

**Edit 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).

**Error Message Notes**... this submenu option is used to view an intermediate text file that provides the detailed list of error messages. If a program is not executed successfully due to some input errors, the specific error number will be generated in the output file. The user may open the output file to locate the error numbers; then find out the exact reasons for the error by looking into the error message note. This submenu automatically invokes the word processor or text editor specified by the user. The default setting is to use the utility program named *notepad.exe* provided by Microsoft Windows®.

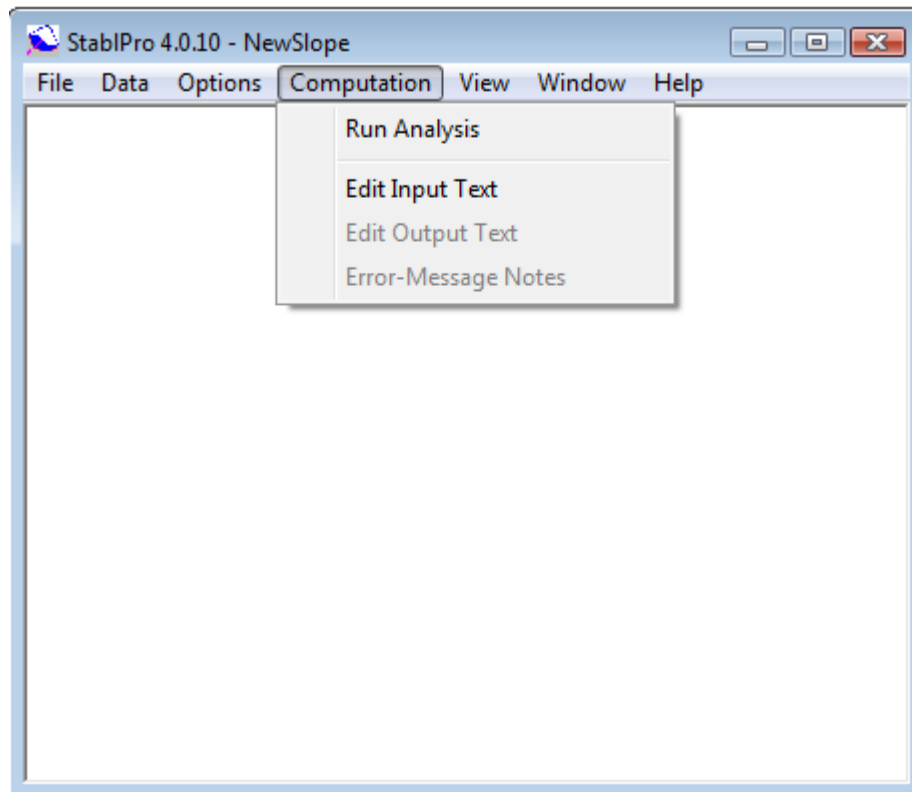


Figure 2.11 Options contained in the Computation menu

## 2.2.6 Graphics Menu

The **Graphics** menu is used to observe plots of 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 2.12, 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 option boxes.

Profile Line..... show user-specified soil profile including the slope geometry.

Profile Numbers ..... show the profile number for easy identification of soil layers.

Profile Coordinates..... Show coordinates of each point on the soil profile that were entered by the user.

Color Soil Layers.... show color on each soil layer for distinction.

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

Piezometric Lines..... Show the piezometric surfaces defined by the user.

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

Reinforce Lines..... Show the layout of the reinforce lines defined by the user..

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

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

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

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

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

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

Pore Water Pressure.... Show the distribution of pore water pressure on the slip failure surface.

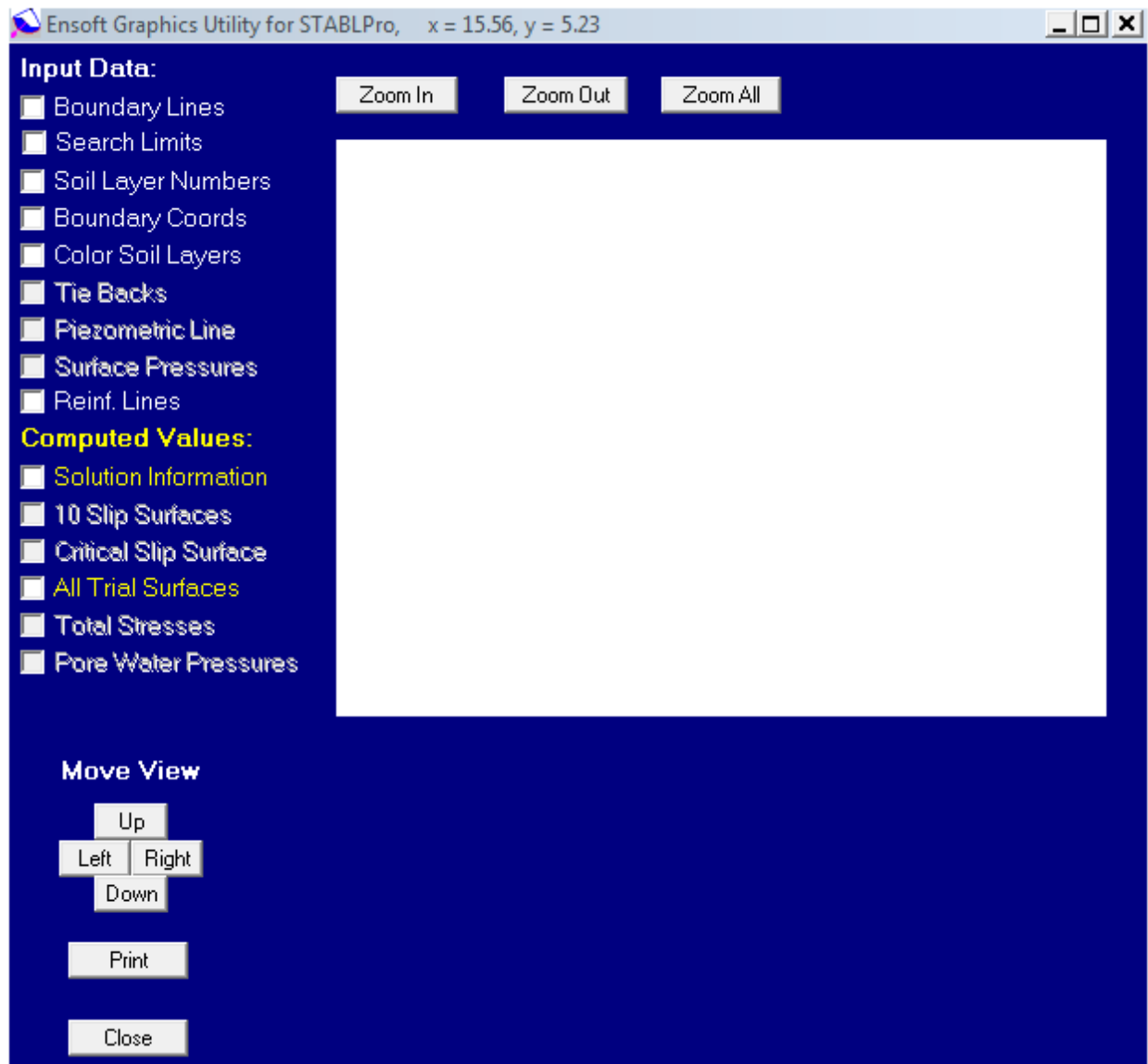


Figure 2.12 Options contained in the Graphics menu

### 2.2.7 Arrangement of Windows

The Window menu provides two standard functions for organizing opened windows and/or minimized window icons. Submenu options, shown in Figure 2.13, 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.

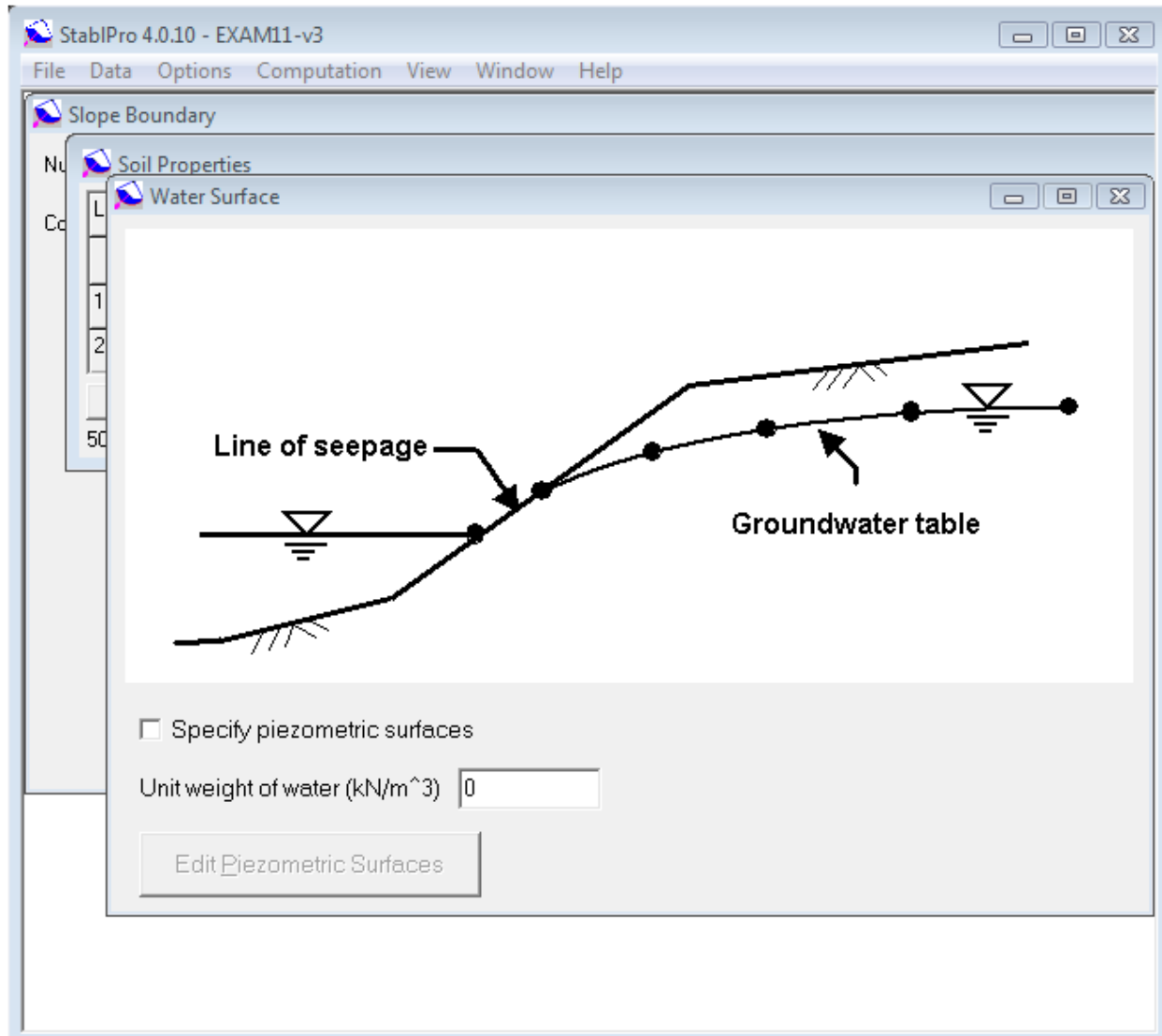


Figure 2.13 Sample options contained in the Window menu

### 2.2.8 Help Files

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 2.14, are briefly described below. The menu may be accessed at any time while in STABLPRO.

**Contents** .....the main reference files for help are accessed through this submenu option. The Help files usually do not provide as much information as the electronic manuals that are also accessible from the **Help** menu.

**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 is a protected file (copyright document) that can only be opened with this viewer and by user's that are running the program in full mode.

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.

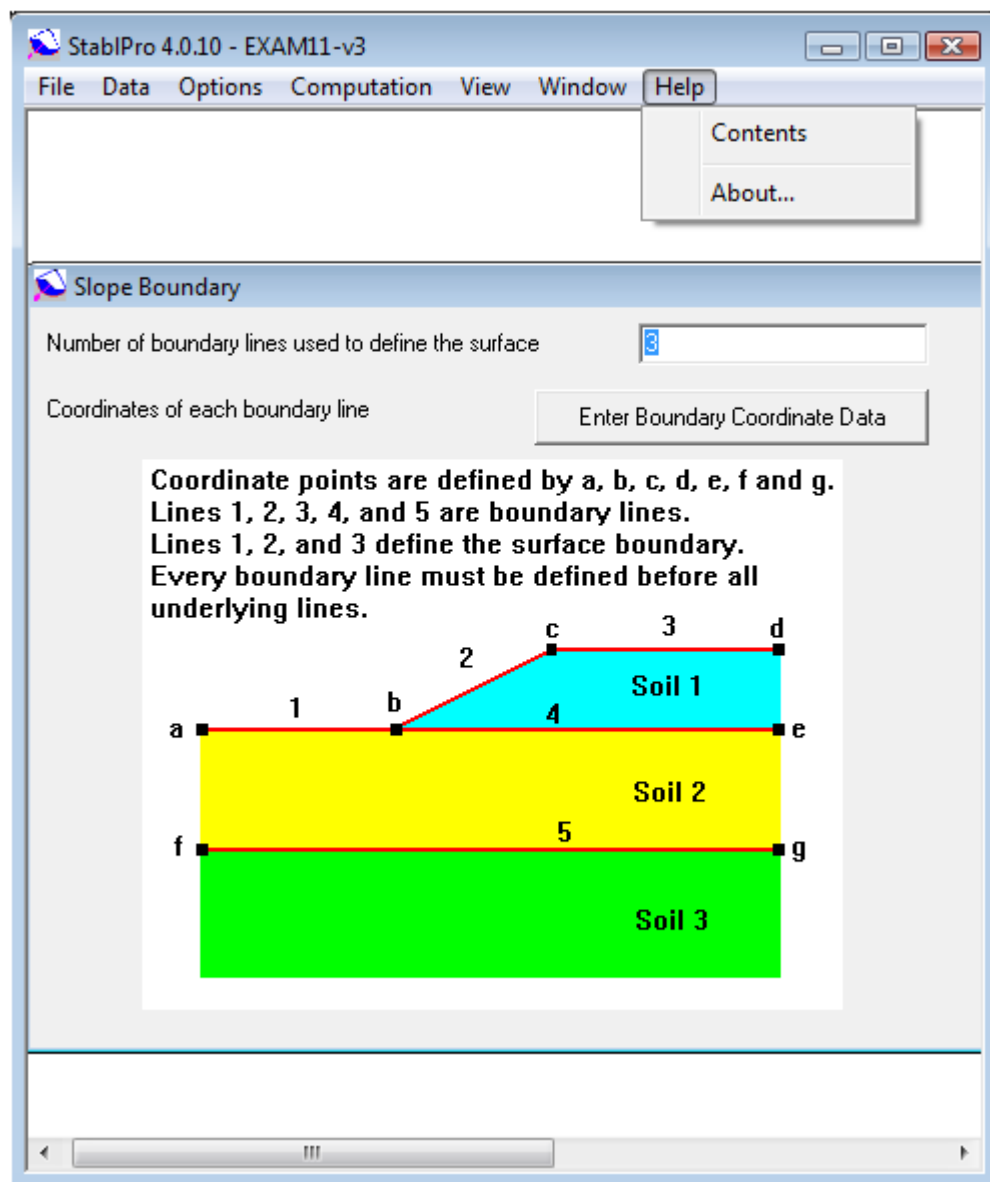


Figure 2.14 Options contained in the Help menu





## **CHAPTER 3. References for Data Input**

### 3.1 Introduction

The DATA Menu consists of different input items for data entry. A total of 8 input items are provided under the DATA Menu. The user may select any one of them without concern for the sequential order. Some of the input parameters are optional and the user can skip those parameters if they are not applicable to the encountered problem. However, Items 1, 2, 3, and 7 are always required. Input-data files created for STABLPRO are provided with a standard file-name extension in the form of \*.sl4d (where \* 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 for the input file. The user may use the mouse to click any of these items for viewing. Consistent units should be used throughout the data input.

STABL is compatible with any system of units which the user may prefer for analysis. If consistent units of length and mass are used, the program will function without error. For example, one may use the following:

**Coordinates:** feet (ft) or Meters (m)

**Unit Weights:** pounds/cubic foot (pcf) or kilograms/cubic meter (kN/m<sup>3</sup>)

**Strength Intercept:** pounds/square foot (psf) or kilograms/square meter (kN/m<sup>2</sup>)

**Pore Pressure:** pounds/square foot (psf) or kilograms/square meter (kN/m<sup>2</sup>)

**Unit Weight of Water:** 62.4 pcf or 9.8 kN/m<sup>3</sup>

The default units in the program are “ft” and “lbs”. Each slope to be analyzed is made left-facing and placed in a first quadrant position so that all coordinates will have positive values. It is necessary to plot the problem's geometry to scale on a rectangular coordinate grid. Coordinate axes should be chosen carefully such that the total problem is defined within the first quadrant. This enables the graphic aspects of the program to function properly. For best resolution and interpretation of output data, the extent of coordinate limits should define the problem geometry, and permit analysis of the most critical failure surfaces. Potential failure surfaces developing beyond the toe or the crest of the slope must be accommodated (Figure 3.1). Deep trial failure surfaces passing below the horizontal axis are not allowed, nor are trial failure surfaces which extend beyond the defined ground surface in either direction. If any coordinate point defining the problem's geometry is detected by the program to lie outside the first quadrant, an appropriate error code is displayed and execution of STABLPRO is subsequently terminated.

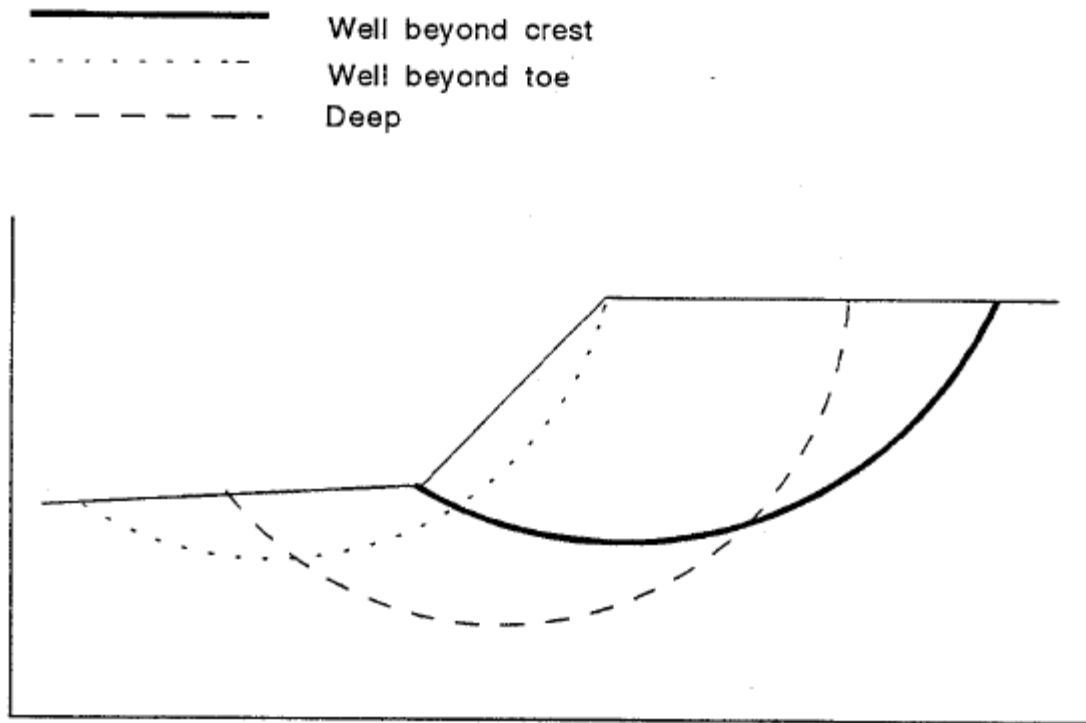


Figure 3.1 Example slope geometry and subsurface profile

### 3.1.1 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 STABLPRO 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 File Menu

This menu contains options related to the management of input-data files and to exit the program. Input-data files created for STABLPRO are provided with a standard file-name extension in the form of *\*filename\*.sl46d* (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 STABLPRO 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 STABLPRO 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 STABLPRO 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 STABLPRO 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 the previous STABLPRO 3.0 version (\*.sld file extension) 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 STABLPRO v3.0 input files to STABLPRO (the latest version) when the user saves the opened file.

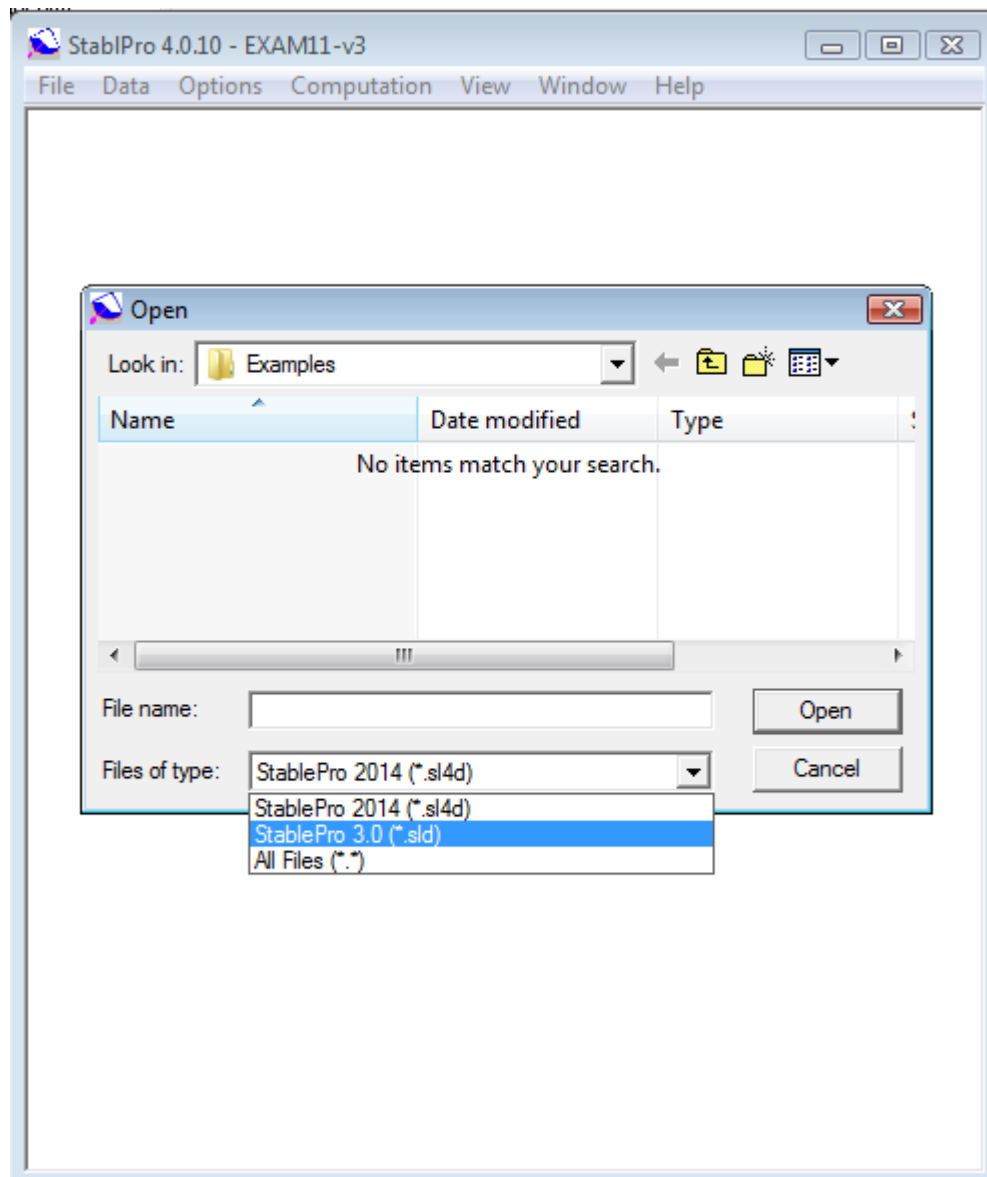


Figure 3.2 Window screen for the File – Open dialog

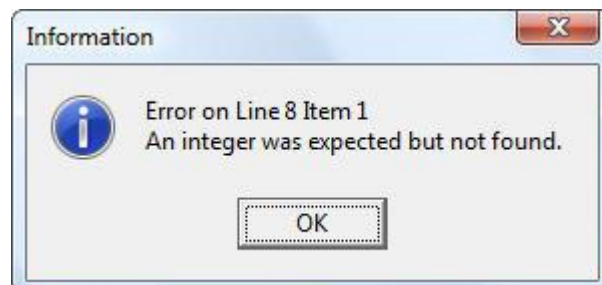


Figure 3.3 Sample message for incomplete or invalid file

### 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 STABLPRO. 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).

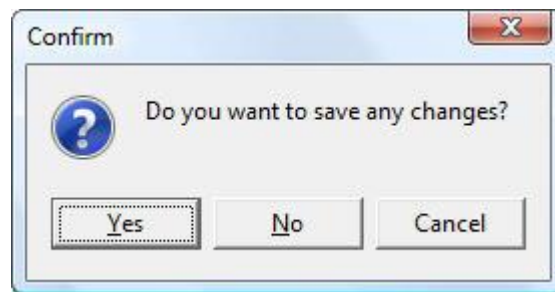


Figure 3.4 Message window advising that changes were not saved to disk

## 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 STABLPRO icon on the upper-left corner of the window, or
- clicking once on the STABLPRO 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.

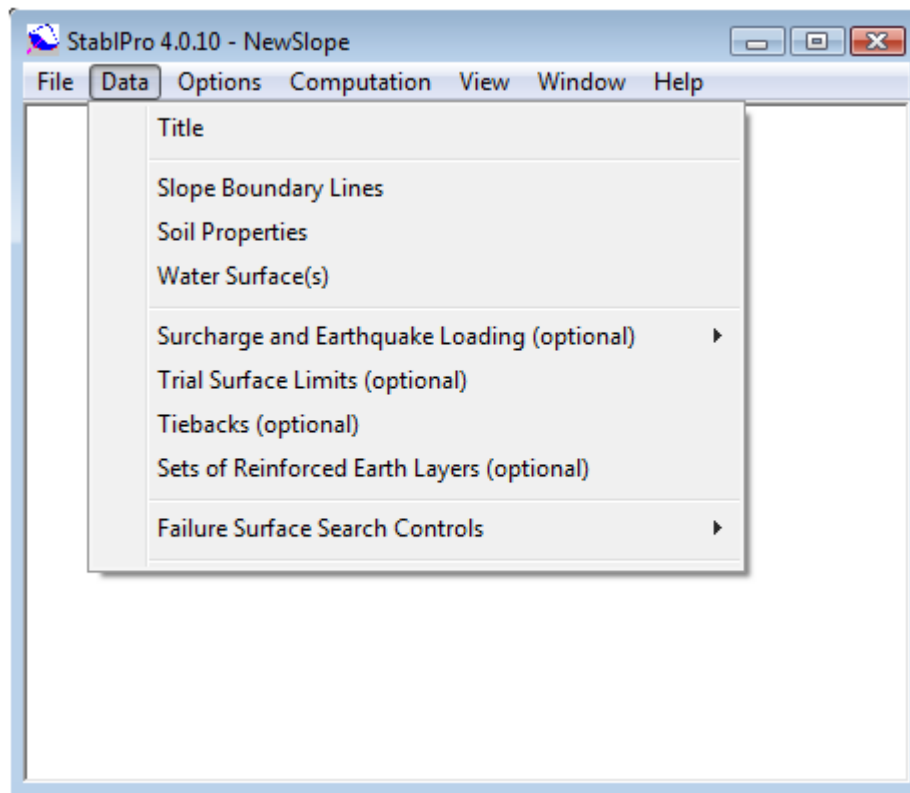


Figure 3.5 Options contained in the Data menu

### 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 of Table 3.1. Note that implicit multiplication (i.e.  $2(4+6)$ ) 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)
<b>CONSTANTS</b>	
<b>Symbol</b>	<b>Value</b>
<b>PI (or pi)</b>	3.1415927
<b>e (or E)</b>	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 is 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 (i.e. 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 – Title

This option activates the window shown in Figure 3.6, where the user can enter a line of text containing a general description for the application problem. Any combination of characters may be entered in the text box in order 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.

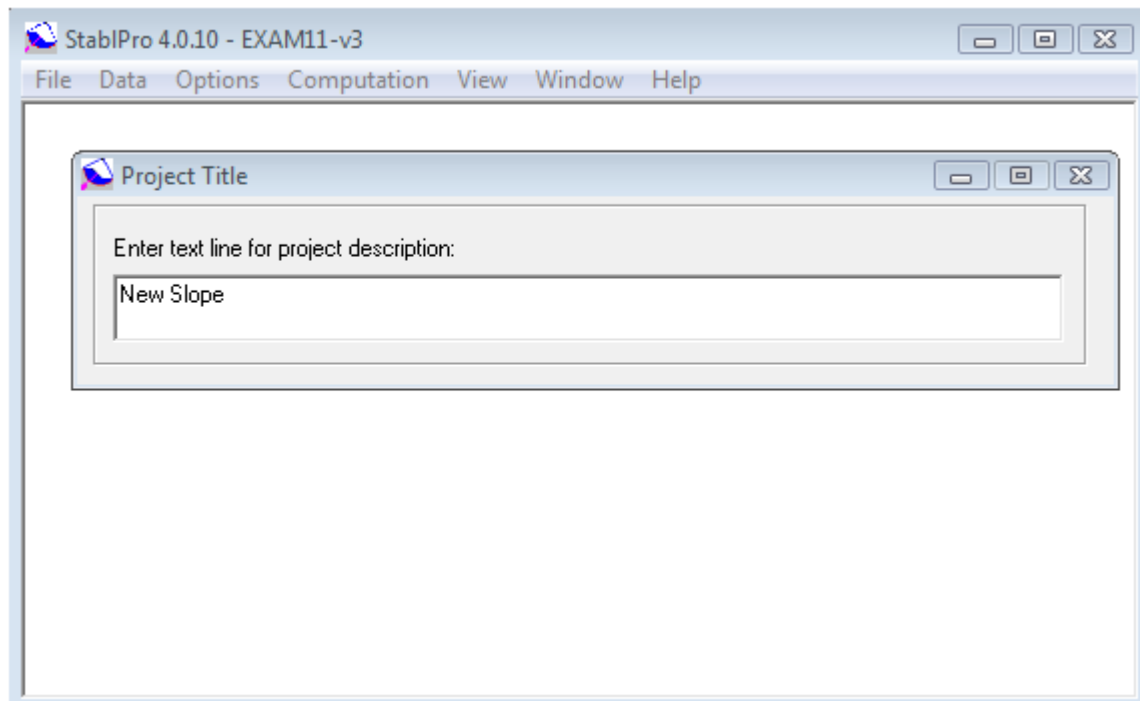


Figure 3.6 Window screen for sample Data - Title



### 3.3.3 Data –Slope Boundary

The input for slope boundaries will appear on the screen if Item - **Slope Boundary** of the Data Menu is selected (Fig. 3.7). Two entry fields are required. The two fields are related to (1) the total number of boundary lines and (2) the boundary lines used to define the surface boundaries. The graphical sketch on the screen will help the user to visualize the definition of the variables.

It should be noted that the slope to be analyzed is made left-facing as shown in 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.

After the number of total boundary lines is entered, the screen will present a grid table to define the coordinates of each profile line. This table is used to label input data of the slope geometry and any subsurface boundaries forming the soil strata. Up to 25 different boundaries can be specified. Five entries are required for each profile line, two for the x and y coordinates at the left end, two for the x and y coordinates at the right end, and one for the soil type beneath the profile line. The x and y coordinates are defined by real numbers, but the soil type should be an integer.

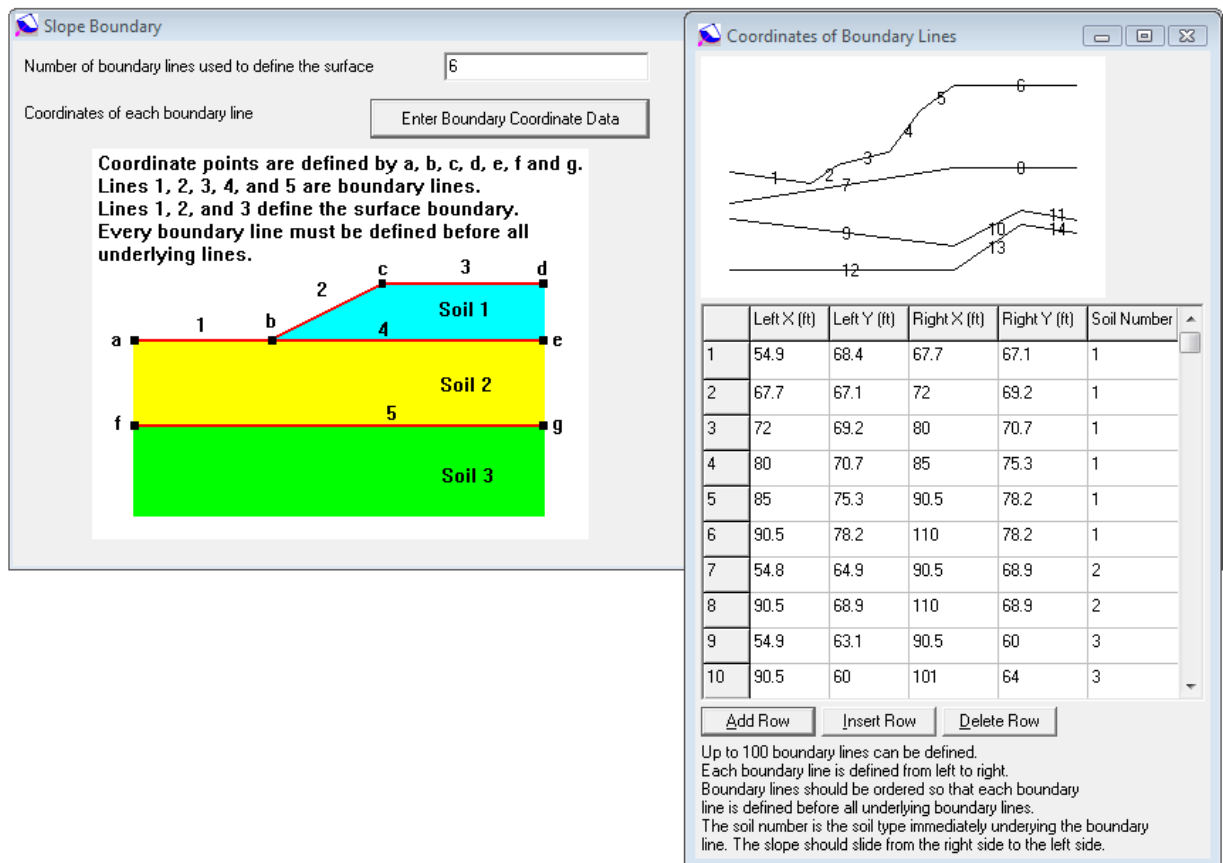


Figure 3.7 Window screen for sample Data – Slope Boundary

Data for soils exhibiting anisotropic properties may be entered on this screen. To open the input screen for strength anisotropy, the user can click the “button” if the soil has anisotropic properties.

### 3.3.4 Data – Soil Properties

The Soil Property item from the Data menu may be clicked and the input screen for soil properties will be shown on the screen (Fig. 3.8). A total of 20 different types of soil can be specified on the screen. 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 soils anisotropic properties as shown in Fig. 3.8. A general description for the input needed under each item of the Data – Soil Properties submenu option is listed below.

#### Soil Type Number

This is the number assigned to each soil type, which corresponds to the entry in earlier section for profile lines. The maximum number of rows for soil layers should be equal to the maximum soil type number been selected in profile entries.

#### Moist Unit Weight

This is the moisture unit weight (in-situ unit weight) for the soil. In the case of 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<sup>3</sup>” 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<sup>3</sup>” is for the SI unit.

#### Isotropic Strength Intercept

This is the cohesive strength  $c$  for an isotropic cohesive soil. Either an effective stress analysis ( $\phi'$ ,  $c'$ ) or total stress analysis ( $c$ ,  $\phi=0$ ) 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<sup>2</sup>” is for the SI unit.

#### Isotropic Strength Angle

This is the internal friction angle for an isotropic cohesionless soil. Either an effective stress analysis ( $\phi'$ ,  $c'$ ) or total stress analysis ( $c$ ,  $\phi=0$ ) 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<sup>2</sup>” is for the SI unit.

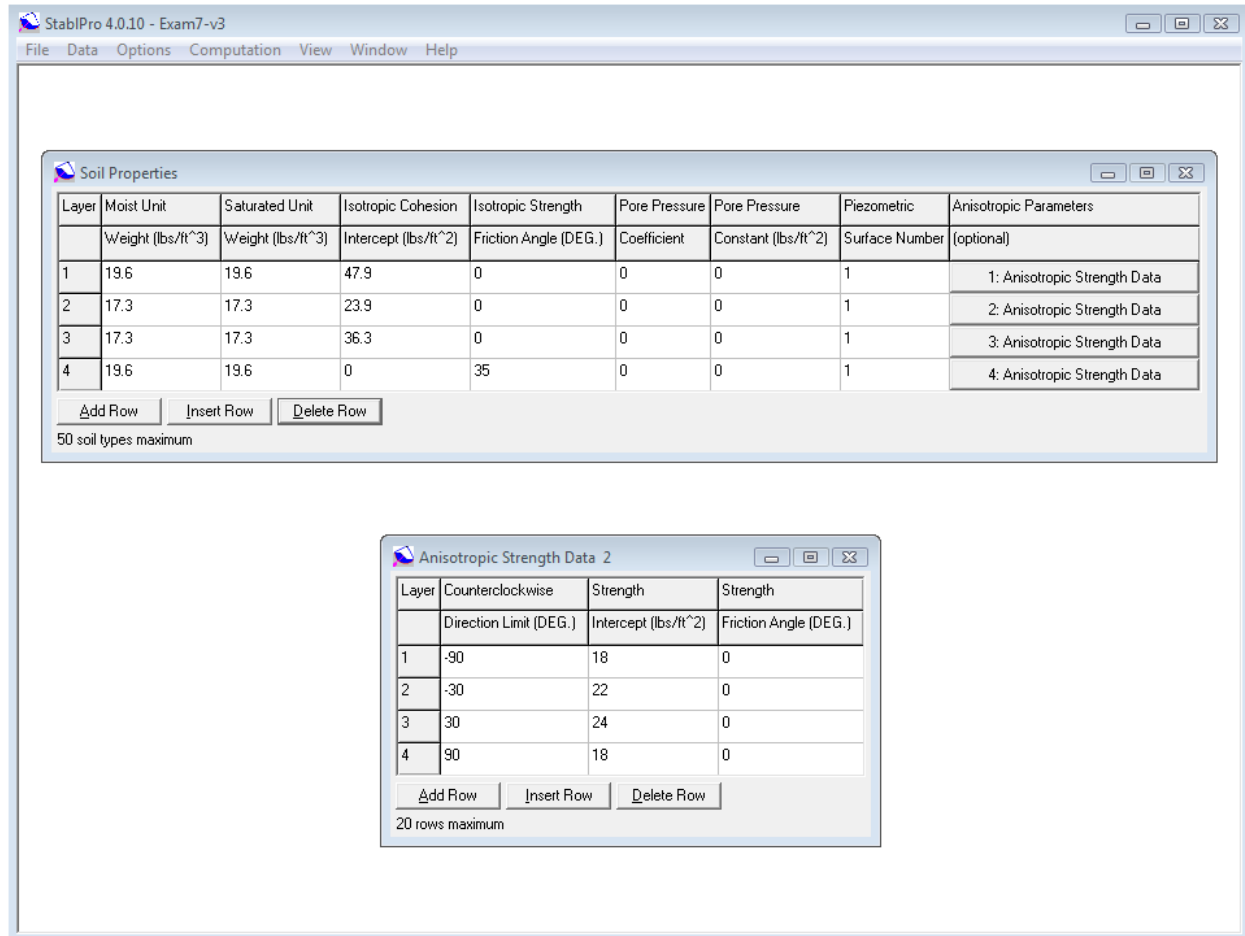


Figure 3.8 Window screen for sample Data – Slope Boundary

### Anisotropic Soil

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 soils anisotropic properties as shown below. 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 ( $\alpha$ ) and the Mohr-Coulomb strength angle ( $\phi$ ) and strength intercept ( $c$ ) for each discrete range. Data for each discrete range are required to be prepared progressing in counterclockwise order, starting with a first range from  $-90$  degrees to  $\alpha_1$  (specifying  $\alpha_1$  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.

### 3.3.5 Water Surface

This submenu is automatically enabled if the user selected to analyze a pile type with a noncircular cross section (under Data – Pile Material). This submenu option allows the user to input dimensions and section properties for piles with noncircular cross sections. A general description for the data needed under each entry of the Data - Noncircular-Section Pile submenu option is listed below and shown in **Error! Reference source not found.**

The WATER option is used to define up to 5 different piezometric levels with slope geometry. The data can be successfully used to assign perched water tables and also to simulate pore-pressure distributions within the soil strata.

To open the input screen for the piezometric surface, the user selects item **Water Surface** from the Data menu, as shown on Fig. 3.9. A total of five piezometric surfaces can be specified on the input screen. For each piezometric surface, the user may use up to 10 points to define the x and y coordinates. When the entry of data appears to be correct, the screen is closed and return will be to the main Data menu.

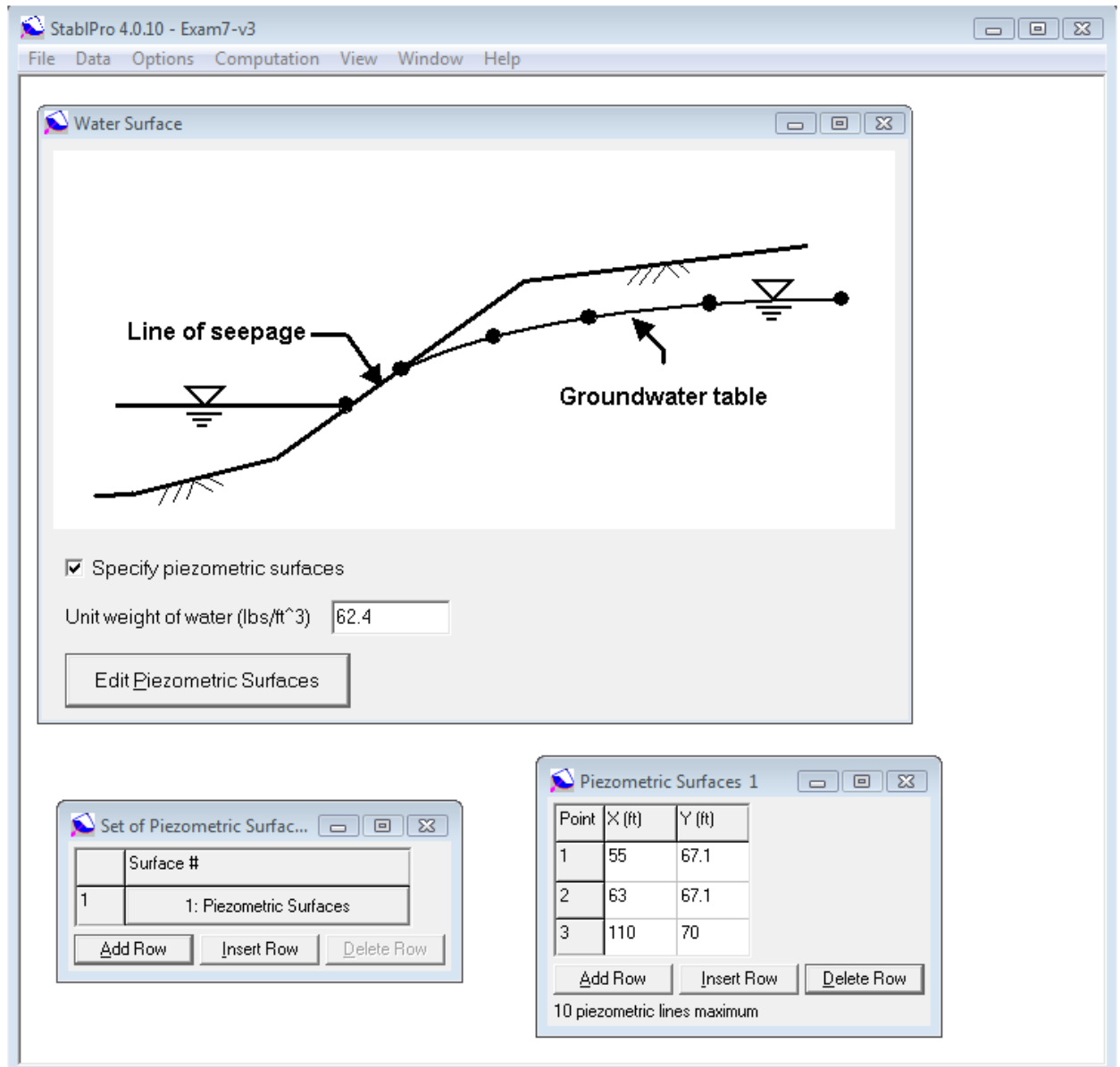
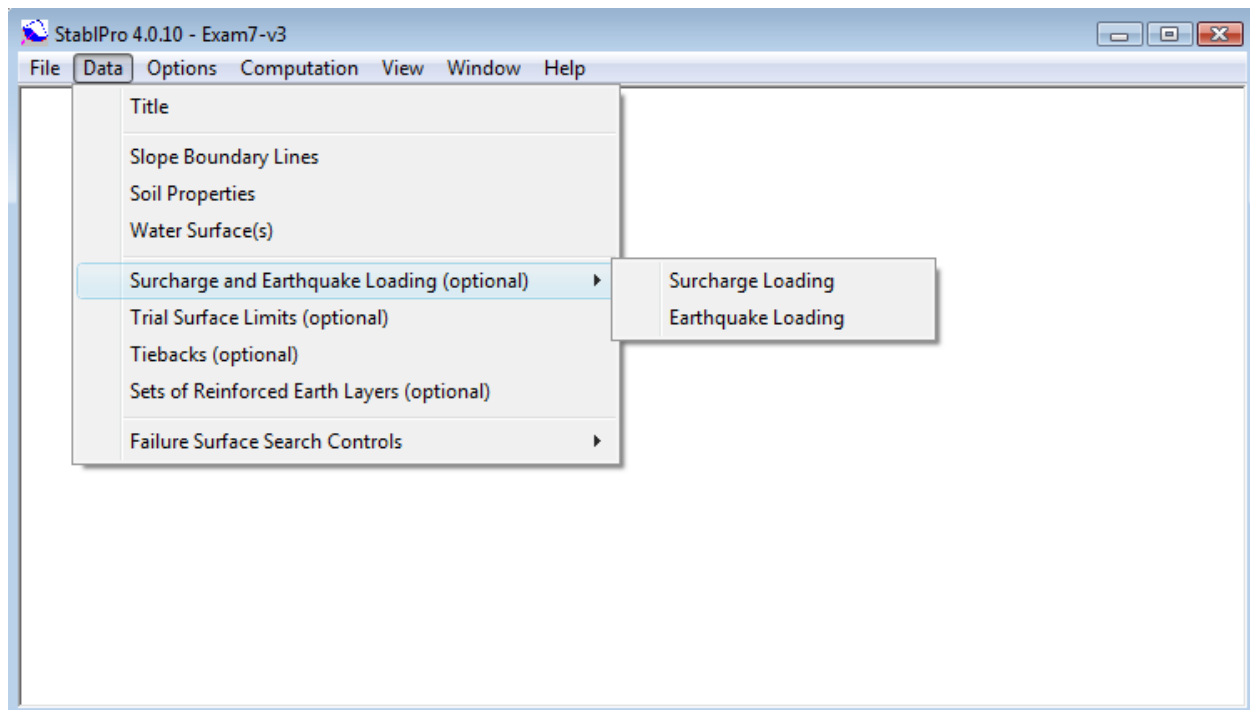


Figure 3.9 Window screen for sample Data – Water Surface

### 3.3.6 Data – Surcharge and Earthquake Loading

External boundary loads which may be 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 intensity may be approximated by a set of equivalent uniformly distributed loads abutting each other. For a pseudo-static earthquake analysis, the sub-menu EQUAKE is used to assign vertical and horizontal coefficients to simulate the design earthquake.

To open the input screen for boundary surcharge loads and earthquake loads, the user selects Item - **Surcharge and Earthquake Loading** from the Data menu. There are two categories for loading: surface surcharge loads and earthquake loads as shown in Fig. 3.10. The user may select one or both loading conditions.



**Figure 3.10 Window screen for sample Data – Surcharge and earthquake Loading**

The boundary surcharge loads may be specified on the input screen, as shown in Fig. 3.11. The user should enter the x coordinates of two end points for each boundary load. The intensity and load inclination are also required for the boundary load.

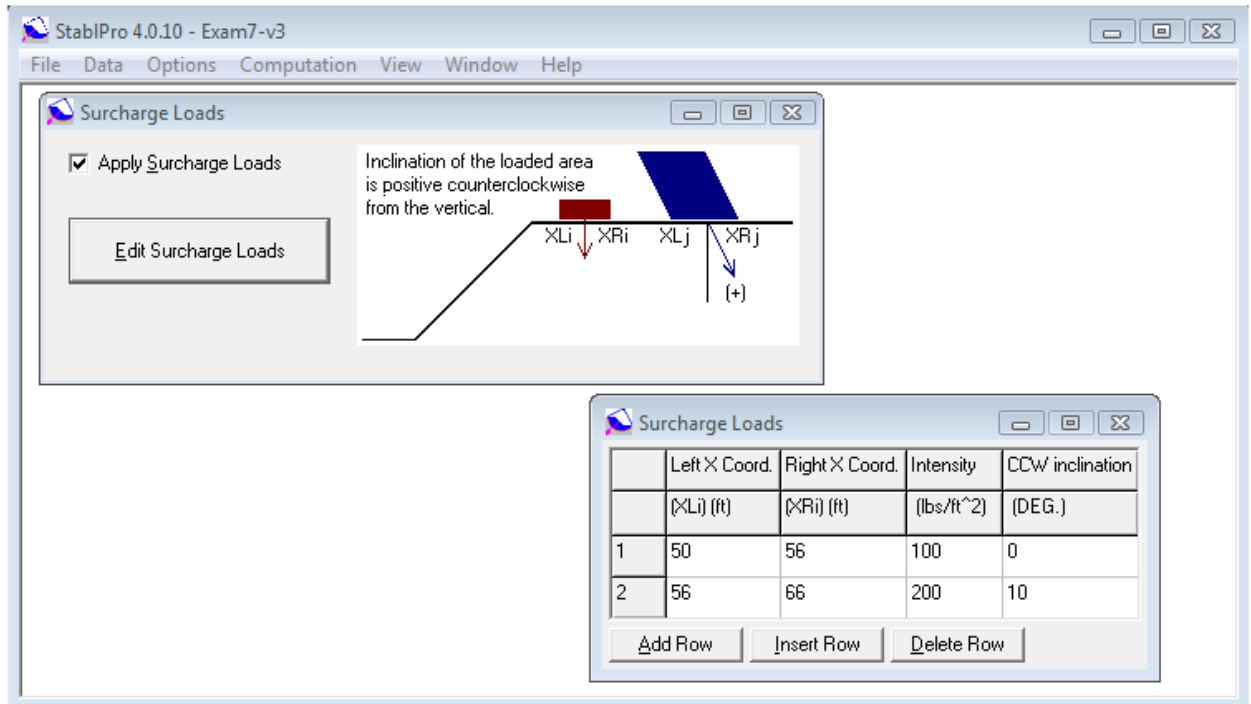


Figure 3.11 Window screen for sample Data – Surcharge and earthquake Loading

If earthquake loading is applicable, values for all three fields designated for the earthquake condition must be entered (Fig. 3.12). The data needed for earthquake loads are the coefficient for horizontal acceleration, the coefficient for vertical acceleration, and cavitation pressure (optional).

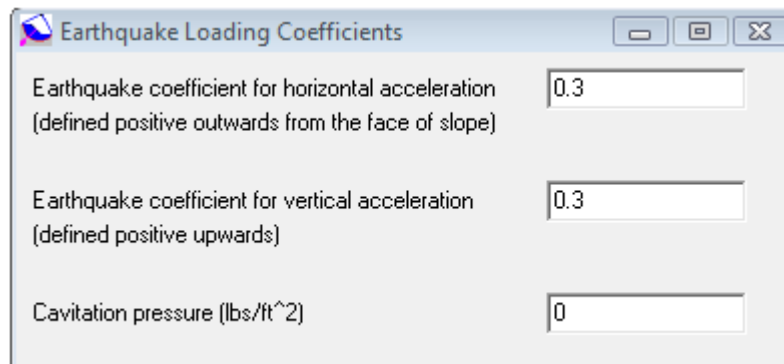


Figure 3.12 Window screen for sample Data – Surcharge and earthquake Loading

### 3.3.7 Data – Trial Surface Limit

Program STABL 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 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 input shown in Fig. 3.13 will appear on the screen by selecting **Trial Surface Limit** from the main Data. A total of 10 generated boundaries can be specified on the screen. The x and y coordinates at the right and left ends are required for each boundary line.

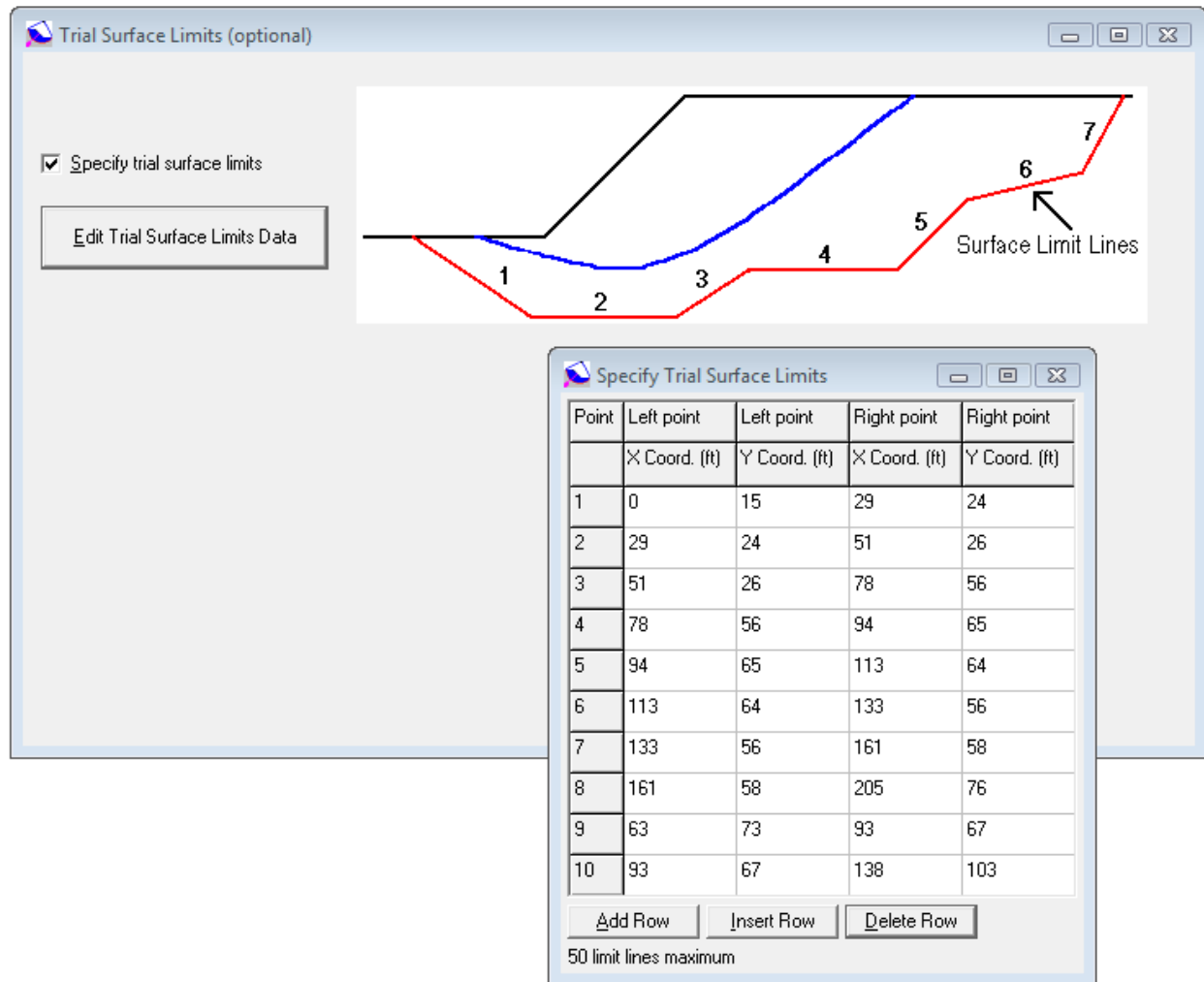


Figure 3.13 Window screen for sample Data – Trial Surface Limit

### 3.3.8 Data – Tieback

Program STABLPRO 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 menu command, 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.

The user may select Item **Tiebacks** from the main Data menu, and a drawing with slope geometry, tieback location, and the failure surface will appear on the screen, as shown in Fig. 3.14. The geometrical data required by the program can be easily interpreted by the user with the graphical presentation. Up to ten tiebacks can be specified on the cross section of a slope. 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. The second column in the table is the boundary number where tieback load is applied. The third column in the table is the X coordinate of the point of application of tieback load (ft) or (m). The fourth column in the table is the Y coordinate of the point of application of tieback load (ft) or (m). This column can be left as zero if the user would like to let the computer generate internally. The fifth column in the table is load per tieback (lbs) or (kN). The spacing on column No. 5 is for the horizontal spacing between tiebacks (ft) or (m). The inclination of tieback load in column No. 6 is measured clockwise from the horizontal plane (deg). The last column of the table is for free length of tieback (ft) or (m) [equal to zero if other than tieback load].

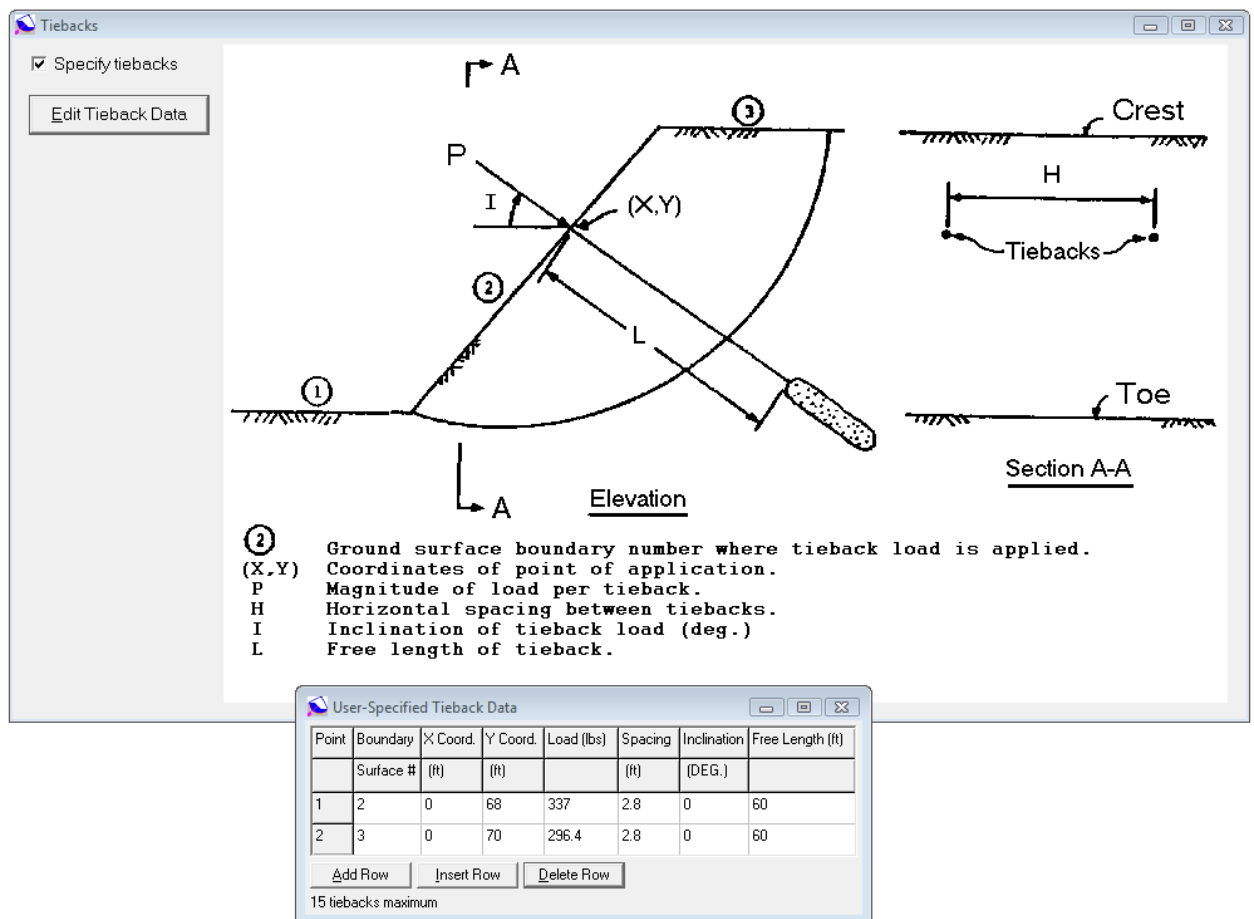


Figure 3.14 Window screen for sample Data – Tiebacks

### 3.3.9 Data – Reinforce Earth Layer

Program STABLPRO allows the user to analyze embankments constructed on soft ground reinforced with one or more layers of reinforcement. The simplified Bishop method for circular slip surface was modified to include the stabilizing moment provided by the reinforcement strips. The user



enters the location of each reinforcement layer, the distribution of available force, and the direction in which the force acts.

The user may select Item **Reinforcement Earth Layers** from the main Data menu, and a drawing with slope geometry, reinforcement location, and the failure surface will appear on the screen, as shown in Fig. 3.15. The data required by the program can be easily interpreted by the user from the graphical illustration. Up to 20 reinforcing layers can be specified. The location of each layer is specified by a series of x,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 reinforce force must be inputted as positive value.

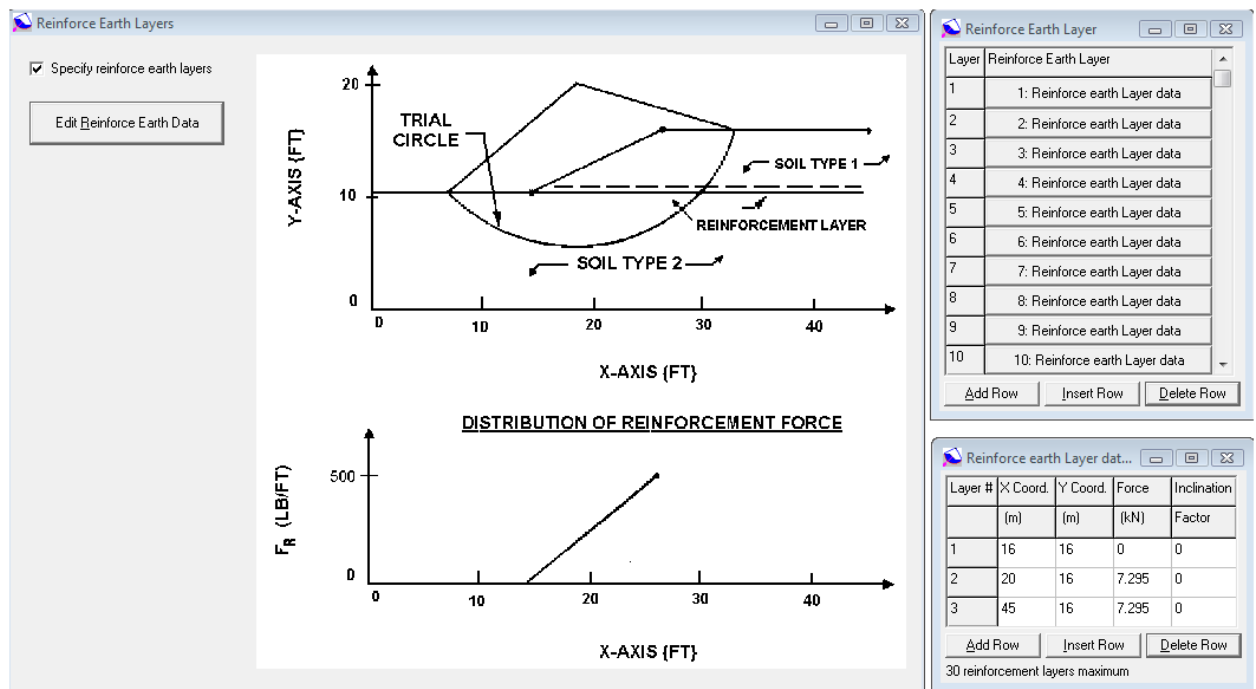
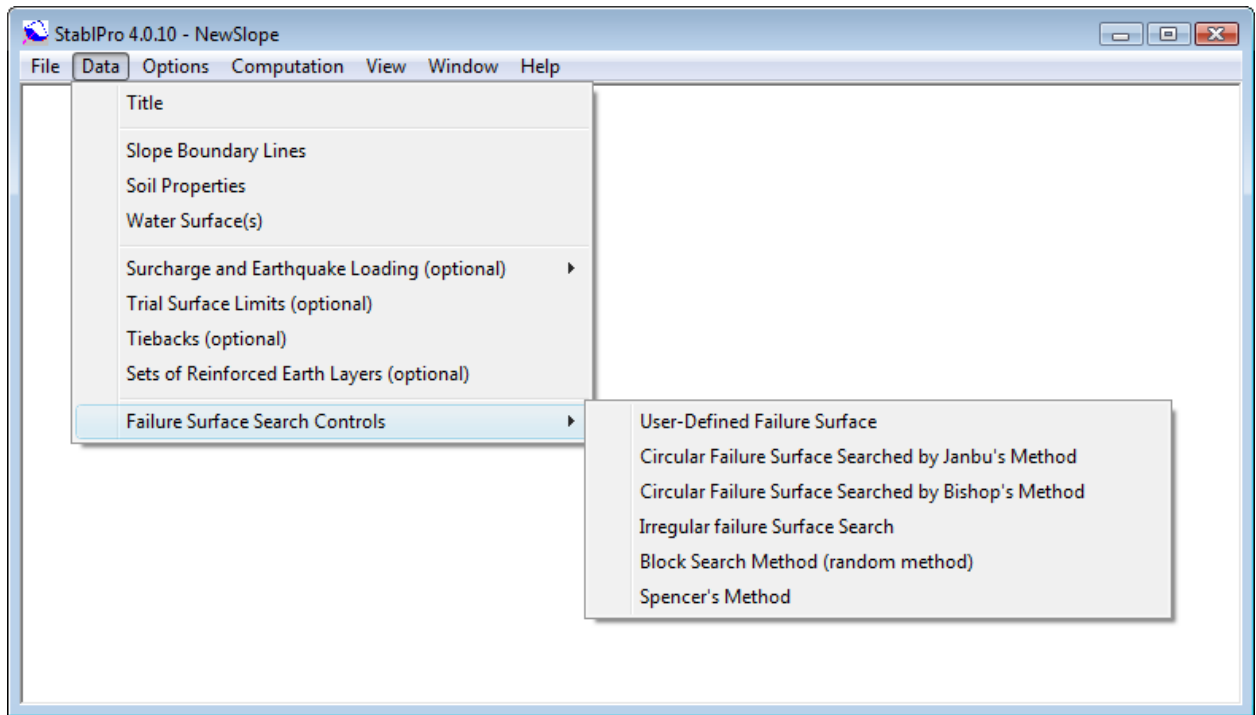


Figure 3.15 Window screen for sample Data – Reinforce Earth Layers

### 3.3.10 Data – Failure Surface Search

Six different methods of analyzing the stability of a slope are available for use in STABLPRO. To specify the failure surface or the automatic-failure search, the user must first select Item **Failure Surface Search** from the Data menu, as shown in Fig. 3.16. The option of specified failure surface is used for determining the factor of safety (FOS) for a specific critical failure surface defined by coordinates input by the user. However, if the user is at an initial- investigation phase, the options for JANBU, BISHOP, and SPENCER (circular surfaces) and irregular surface search may be specified to utilize the program's unique capability to generate critical failure surfaces in a random manner. The user needs only to define the initiation and termination limits of the failure surfaces.



**Figure 3.16 Window screen for sample Data – Failure Surface Search**

If block-type analysis is also required, the BLOCK option allows the user to generate random blocks for analysis. For these blocks, the user can manipulate the size of the block zones to arrive at the minimum FOS. Thus, by specifying the geometry and soils for the specific slope, the user can perform numerous operations, using three different type of critical failure surfaces, to arrive at the most probable value for the FOS of the slope.

In summary, Program STABLPRO features unique random techniques for 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 shape. The user may also specify a predetermined failure surface for the computation of the factor of safety.

Since significantly more computation time is required for 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 STABLPRO capabilities will be realized if the user first investigates a number of potential failure surfaces using one of STABL's 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 SPENCR option to obtain a factor of safety (FOS) satisfying both force and moment i.e., complete equilibrium.

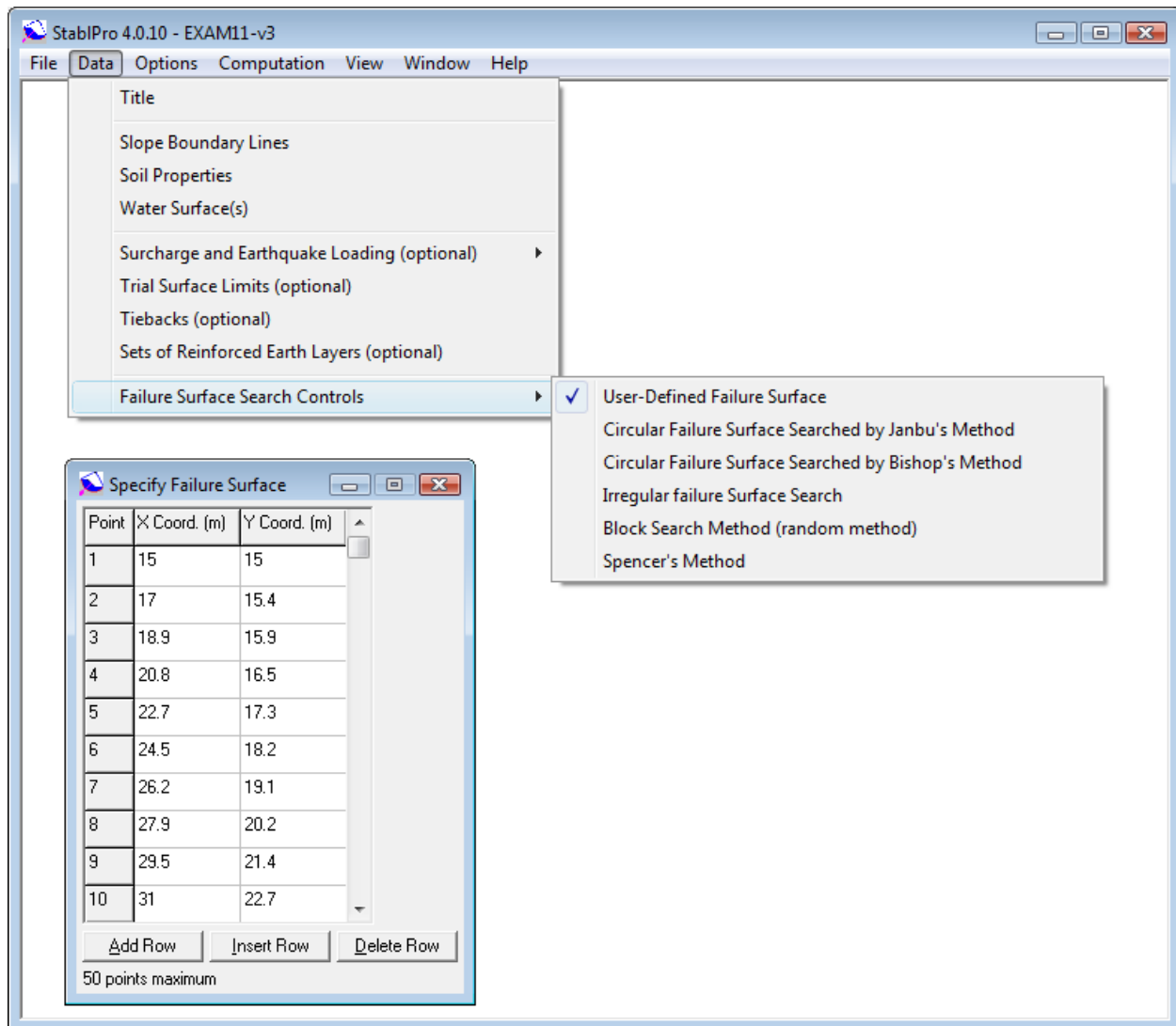
When a user-input potential failure surface is analyzed, the program outputs the value of the factor of safety with respect to force equilibrium ( $F_f$ ), the value of the factor of safety with respect to moment equilibrium ( $F_m$ ), and the angle of the interslice forces ( $\theta$ ) calculated during iteration, along with the value of FOS and  $\theta$  satisfying complete equilibrium. When a user-input potential failure surface is analyzed, the coordinates of the line of thrust, the ratio of the height of the line of thrust above the sliding surface to the slice height for each slice, and the values of the interslice forces are all output.

The only input restrictions require that specification of the “SPENCR” option occur prior to specification of the method of surface generation and solution, i.e., SURFAC, CIRCL2, etc., and the slope angle be greater than zero (deg) and less than or equal to 90 (deg).

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

### **Specific Failure Surface**

Program STABLPRO allows the user to specify a predefined failure surface. To enter the data for the coordinates of points on the failure surface, Item **Specific Failure Surface** may be selected from the dialog box of Failure Surface Search. The input screen will appear as shown in Fig. 3.17. A total of 20 points may be used to define the failure surface. The x and y coordinates are required for each point.



**Figure 3.17** Window screen for sample Data – Failure Surface Search/Specific Failure Surface

### Janbu's Method

Program STABLPRO can use Janbu's procedures to search for the failure surface. If the user selects Item **Circular Search-Janbu's Method** from the dialog box of Failure Surface Search, set of text boxes will appear on the screen, as shown in Fig. 3.18. 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 in the screen. The graphical sketch on the screen will help the user to visualize the definition of the variables. After all the data are entered, the screen is closed and the program will return to the Data menu.

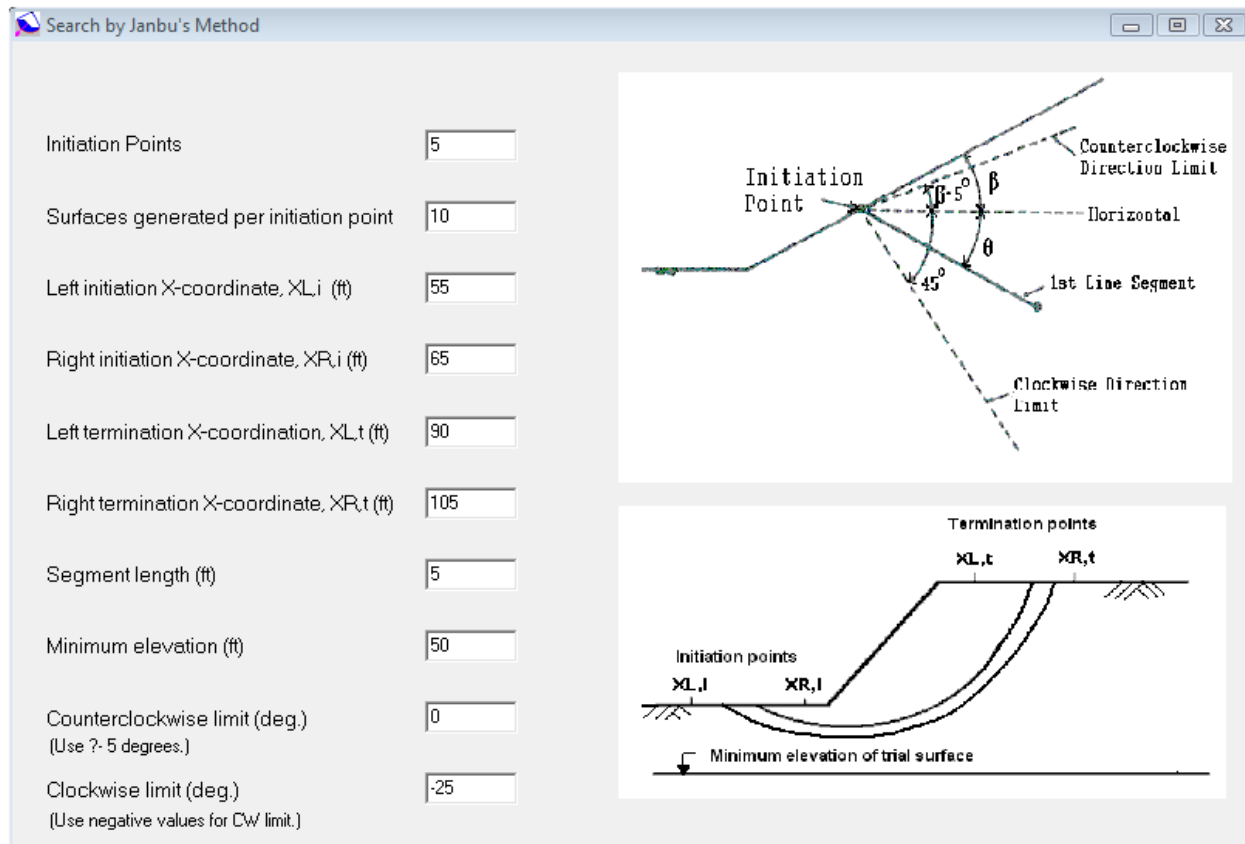
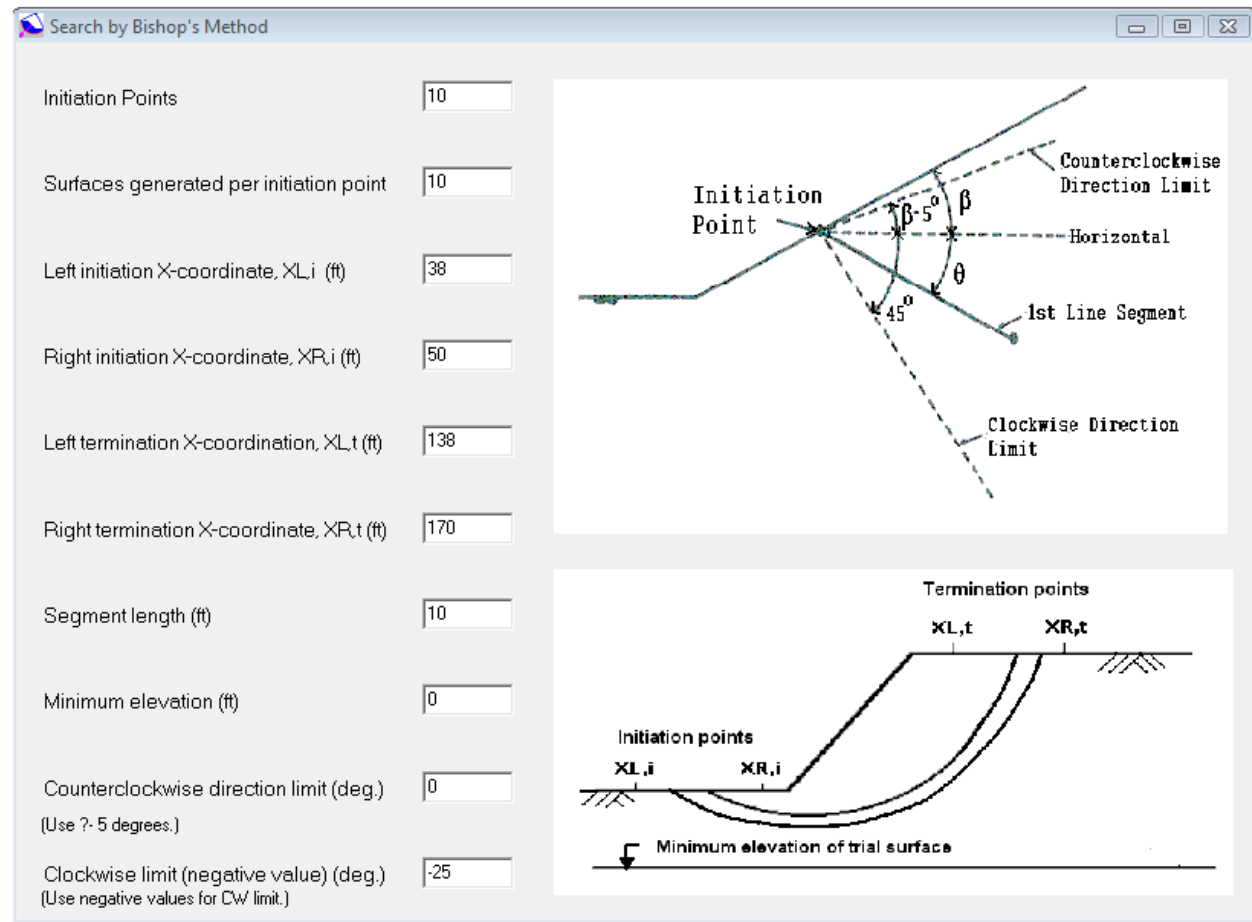


Figure 3.18 Window screen for sample Data – Failure Surface Search/Janbu's Method Surface

### Bishop's Method

Program STABLPRO can use the simplified Bishop's procedures to search for the failure surface. If the user selects the item **Bishop's Method** from the dialog box of Failure Surface Search, a set of text boxes will appear on the screen, as shown in Fig. 3.19. The geometrical data required by the program can be easily entered by the user with the graphic presentation. A detailed description of the variables is given in the screen. The input format is similar to the previous screen for Janbu's method. After all the data are entered, the screen is closed and the program will return to the Data menu.



**Figure 3.19 Window screen for sample Data – Failure Surface Search/Simplified Bishop's Method**

### Irregular Surface Search by Janbu's Method

Program STABLPRO can use Janbu's procedures to search for an irregular failure surface. If the user selects the Item **Irregular Surface Search** from the dialog box of Failure Surface Search, a table will be presented for data entry as shown in Fig. 3.20. A detailed description of the variables is given in the screen. After all the data are entered, the screen is closed and the program will return to the main Data menu.

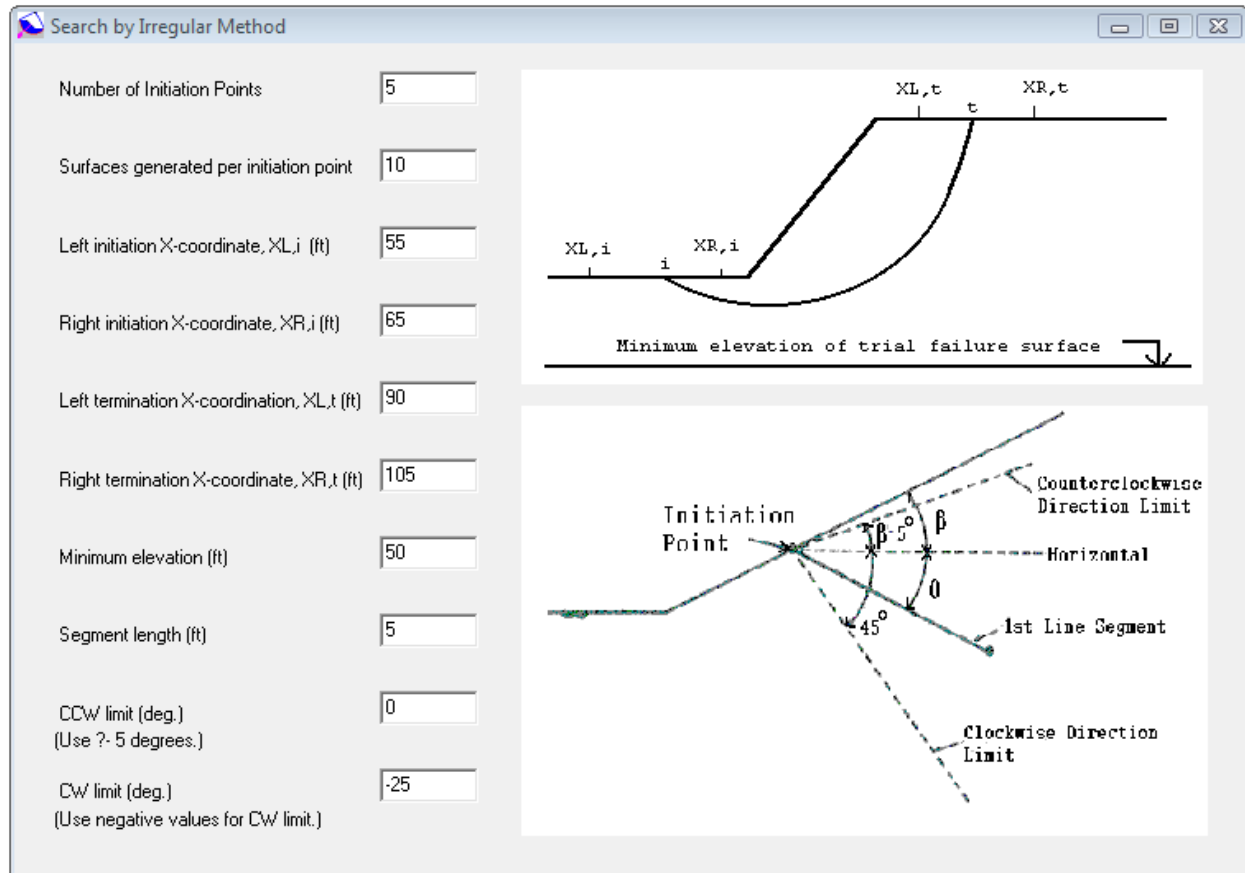


Figure 3.20 Window screen for sample Data – Failure Surface Search/Irregular Surface Search by Janbu's Method

### **Block Method**

Program STABLPRO can use Rankine's theory to generate the surface of a sliding block. If the user selects the Item **Block Method** from the dialog box of Failure Surface Search, a table will appear on the screen, as shown in Fig. 3.21. The data for Irregular Surface Search employing Janbu's Method. The data fields for each block are provided by grid cells. The definition of each variable is given in detail in the screen. After all the data are entered, the screen is closed and the program returns to the main Data menu.

**Search by Block Method**

Total number of surfaces to be generated:

Segment length (ft):

Boxes used to generate the base of central block:

**Box Data**

Box #	Left End X (ft)	Left End Y (ft)	Right End X (ft)	Right End Y (ft)	Vertical Side
					Length (ft)
1	22	14.5	24	14.5	7
2	70	19.5	72	19.5	5

Figure 3.21 Window screen for sample Data – Failure Surface Search/Block Method

### Spencer's Method

Program STABLPRO can use Spencer's theory to generate the critical sliding surface. If the user selects the Item **Spencer's Method** from the dialog box of Failure Surface Search, a table will appear on the screen, as shown in Fig. 3.22. Spencer's method of slices has been incorporated into STABL5M only (not available in Program STABL4M) to enhance the versatility of the program.

An estimate of the slope of the interslice forces ( One half the user input slope angle is used by the program as an initial estimate of the slope of the interslice forces) is the only required input parameter.

Since significantly more computation time is required for 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 STABL5M capabilities will be realized if the user first investigates a number of potential failure surfaces using one of STABL's 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 SPENCR 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 the value of the factor of safety with respect to force equilibrium ( $F_f$ ), the value of the factor of safety with respect to moment equilibrium ( $F_m$ ), and the angle of the interslice forces (theta) calculated during iteration, along with the value of FOS and theta satisfying complete equilibrium. When a user-input potential failure surface is analyzed, the coordinates of the line of thrust, the ratio of the height of the line of thrust above the sliding surface to the slice height for each slice, and the values of the interslice forces are all output.

The only input restrictions require that specification of the "SPENCR" option occur prior to specification of the method of surface generation and solution, i.e., SURFAC, CIRCL2, etc., and the slope angle be greater than zero (deg) and less than or equal to 90 (deg).

**Figure 3.22 Window screen for sample Data – Failure Surface Search/Simplified Spencer's Method**



## 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 3.23. In general, the following specific units of measurements 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 to 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 input data have been converted appropriately.

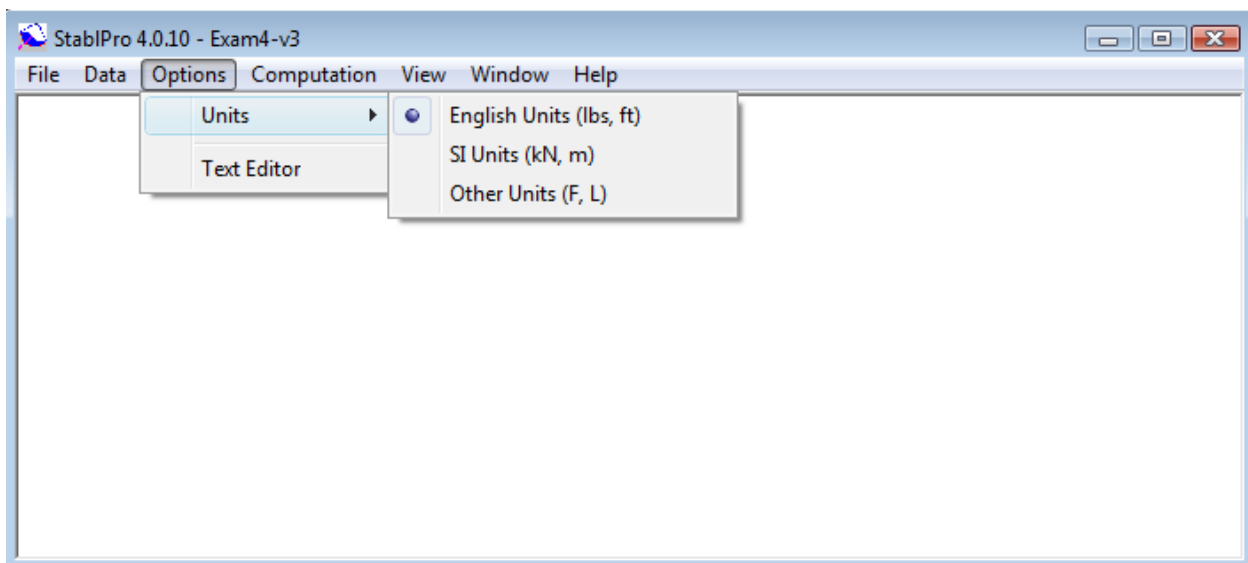


Figure 3.23 Options for units selection

### 3.4.2 Options – Text Editor

The user should input in this box (Figure 3.24) 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 STABLPRO 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 XP, VISTA and Windows 7/8. 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*).

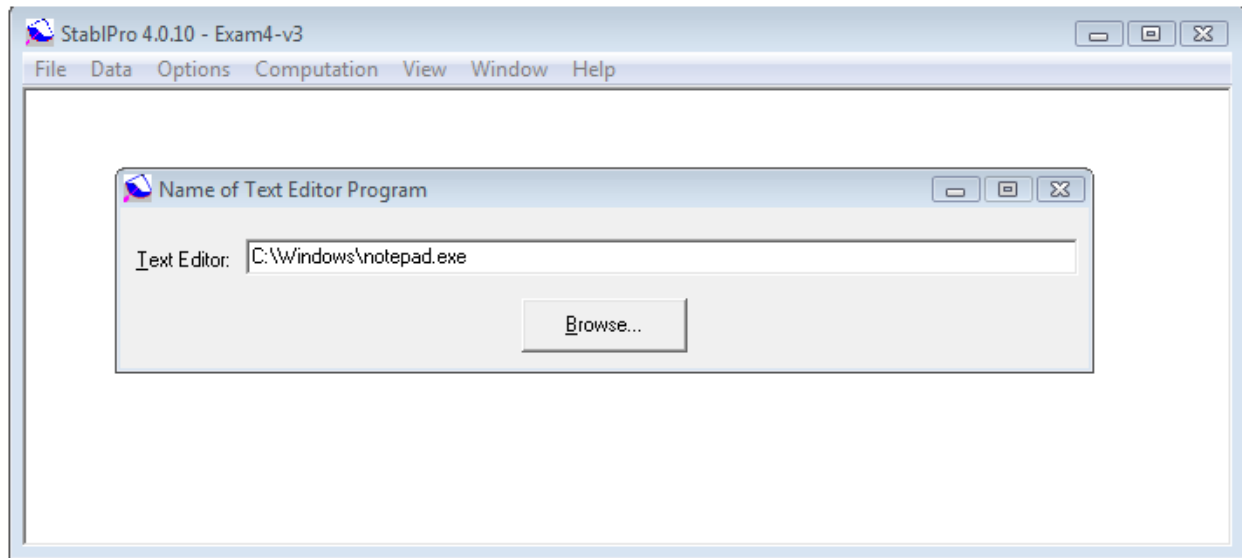


Figure 3.24 Options – Control Options

### 3.5 Help Menu

The **Help/Contents** submenu starts the standard help interface for guidelines on data input of the STABLPRO program. The **Help/Contents** submenu is limited in this program release since better formatted data is available in the electronic User's Manual.

The **Help/User's Manual** will start up the default installed version of Adobe Acrobat or Adobe Reader and open the installed PDF version of the standard User's Manual of the STABLPRO program. The Adobe Reader program is freely distributed by Adobe Systems Inc. at [www.adobe.com](http://www.adobe.com)

The **Help/Technical Manual** will start up a viewer of a protected file for the electronic version of this manual. The Technical Manual is copyrighted and only works when the proper USB dongle is connected to the computer in use.

If the Technical Manual is not opening with Acrobat or Reader (while having the proper USB key connected to the computer in use) then perhaps the Adobe software is not configured correctly. Start Adobe Reader (or full Adobe Acrobat) then click on "Edit/Preferences" and "Internet" under "Categories". Please make sure that a check mark is placed under "Display PDF in Browser" then click OK and exit Reader. You can then try to run the Technical Manual once again.

The **Help/About...** submenu provides general references about the program (program version, date, maintenance expiration date, USB serial number) and how to reach Ensoft, Inc. for technical support or sales.

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](http://www.ensoftinc.com)). Users will be able to download,

install and run in full mode any STABLPRO program release that is older than their maintenance expiration date.

## **CHAPTER 4. References for Program Execution and Output Reviews**

## 4.1 Introduction

CHAPTER 4 presents options related to 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 about 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 description 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 program STABLPRO.

The user should remember to save the input data under an user-specified name before executing the analytical module. When saving data to disk, STABLPRO will automatically add an extension of the type \*.ap6d to the name of the input file.

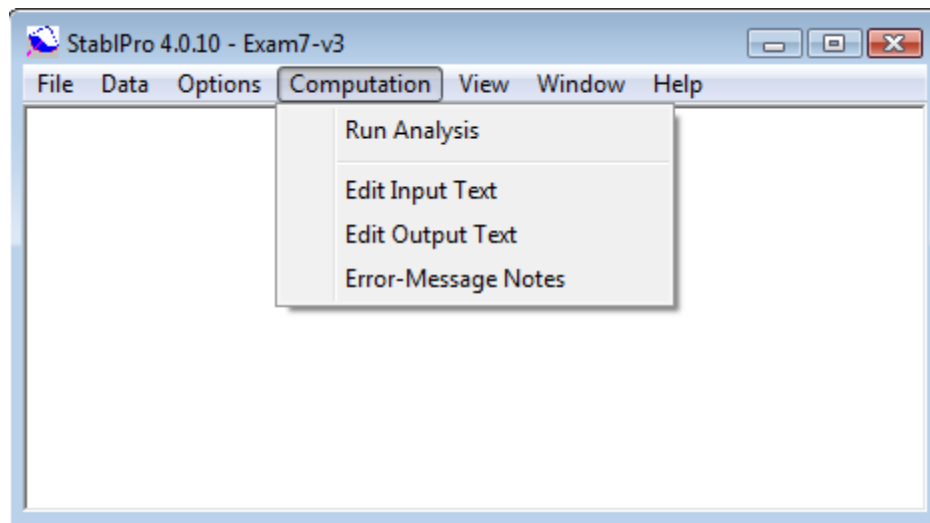


Figure 4.1 Command options contained in the Computation menu.

When the execution process is finished the active command is returned to the main STABLPRO 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 *\*.sl4r*. 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 *\*.sl4o*. 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 – Edit 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 *\*.sl4d* by program STABLPRO. Use of the notepad program for editing the input data is shown in Figure 4.2.

#### **4.2.3 Computation - Edit Processor Run Notes**

This submenu option is used to edit an intermediate text file that may be produced during each analytical run. This feature is not used in early editions of STABLPRO but in the future it will include 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 *\*.sl4r*.

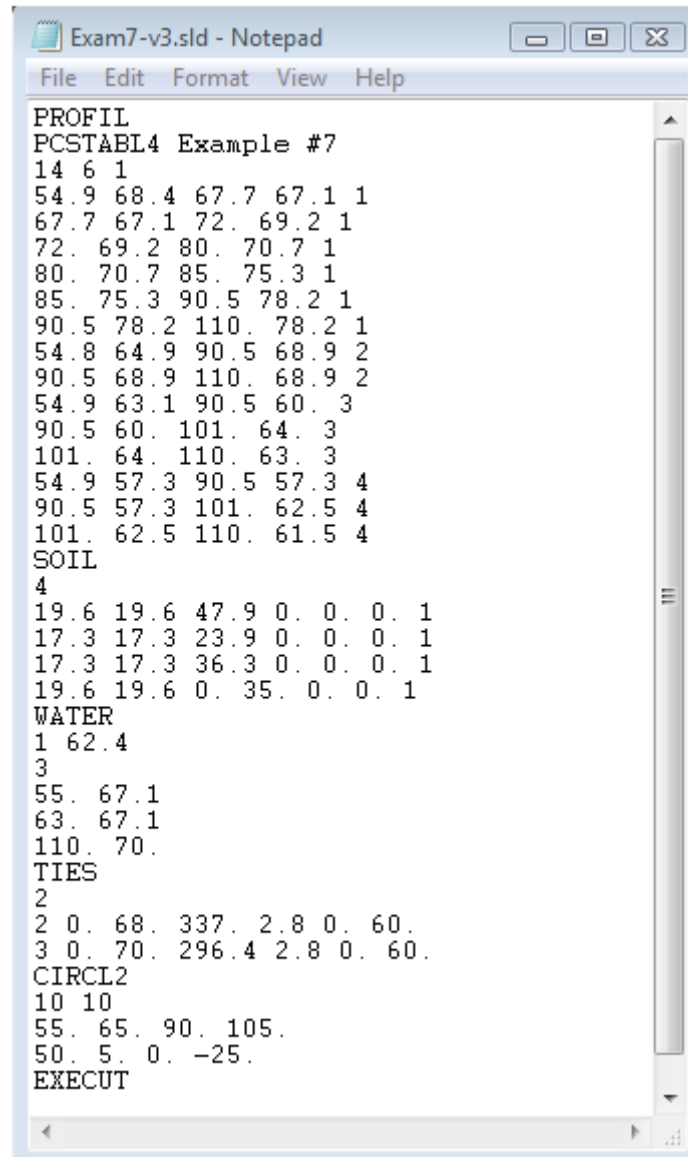


Figure 4.2 Sample use of Microsoft Notepad® for editing input text of Example Problem 7 (may change with time).

#### 4.2.4 Computation – Edit 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 *\*.sldo*. Use of Microsoft Notepad® for editing the output file for Example Problem 1 is shown in Figure 4.3.

```

** STABLPro V2014 **

Upgraded from
FHWA-PCSTABLE

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

Run Date:
Time of Run:
Run By:
Input Data Filename:
Output Filename:
Plotted Output Filename:

PROBLEM DESCRIPTION   PCSTABL4 Example #7

BOUNDARY COORDINATES
  6 Top   Boundaries
 14 Total Boundaries

Boundary   X-Left   Y-Left   X-Right   Y-Right   Soil Type
No.        ft.      ft.      ft.       ft.      Below Bnd
-----
1          54.90    68.40    67.70     67.10     1
2          67.70    67.10    72.00     69.20     1
3          72.00    69.20    80.00     70.70     1
4          80.00    70.70    85.00     75.30     1
5          85.00    75.30    90.50     78.20     1
6          90.50    78.20    110.00    78.20     1
7          54.80    64.90    90.50     68.90     2
8          90.50    68.90    110.00    68.90     2
9          54.90    63.10    90.50     60.00     3
10         90.50    60.00    101.00    64.00     3

```

Figure 4.3 Sample use of Microsoft Notepad © for editing the output-text file of Example Problem 7 (may change with time).

### 4.3 View Menu

The View menu is used to observe graphics of output data provided by a successful program run. Options for the observation of slope geometry, soils layers, and critical failure surface under View 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. Options of graphics features (Fig. 4.4) 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 option boxes.



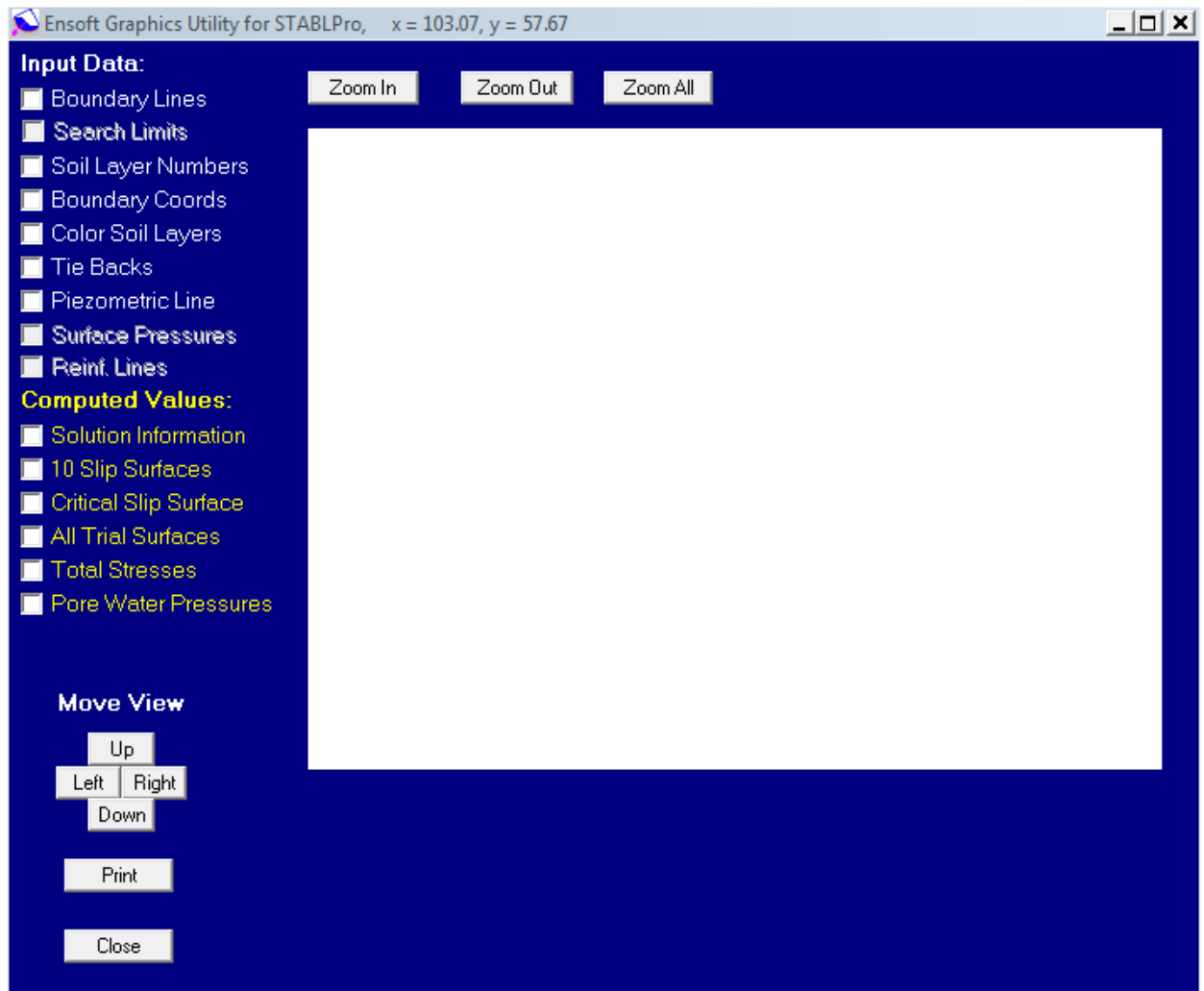


Figure 4.4 Graphics screen and options buttons.

### Profile Line

The user may select this check-box option to observe a graphical representation of profile lines for the slope geometry and soil layers as shown in Fig. 4.5.

### Profile Numbers

The user may select this check-box option to observe the profile numbers on the graphical representation for the slope geometry and soil layers as shown in Fig. 4.5.

### Profile Coordinates

The user may select this check-box option to observe the profile coordinates on the graphical representation for the slope geometry and soil layers as shown in Fig. 4.5.

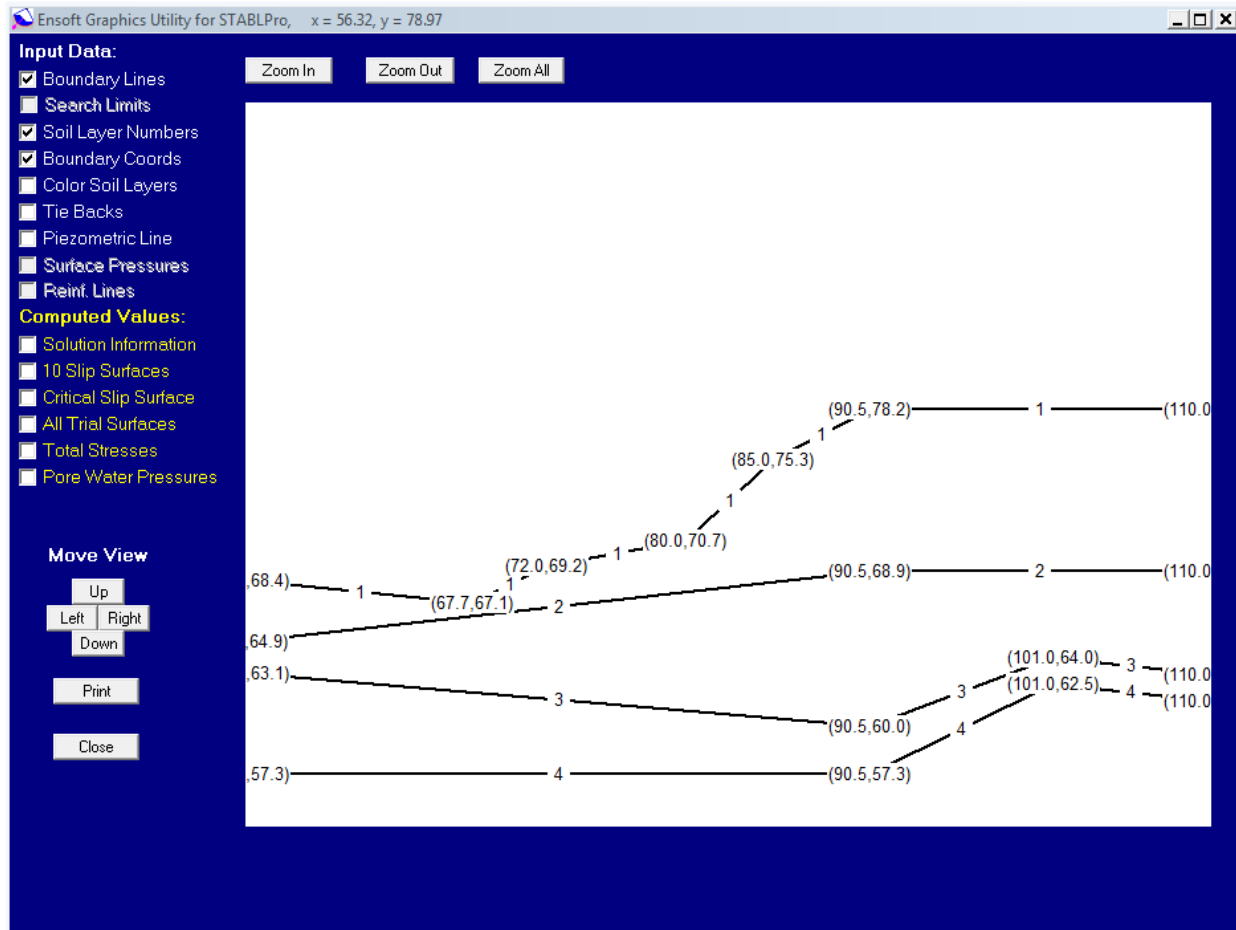


Figure 4.5 Graphics presentation for Boundary Line, Soil Layer Number, and Boundary Coordinates.

### Color Soil Layers

The user may select this check-box option to color the soil layers on the graphical representation. It will provide a better results if the soil layers are not cross-over each others as shown in Fig. 4.6.

### Tiebacks

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

### Piezometric Lines

The user may select this check-box option to observe a graphical representation of pierometric surfaces within the slope geometry and soil layers as shown in Fig. 4.7.

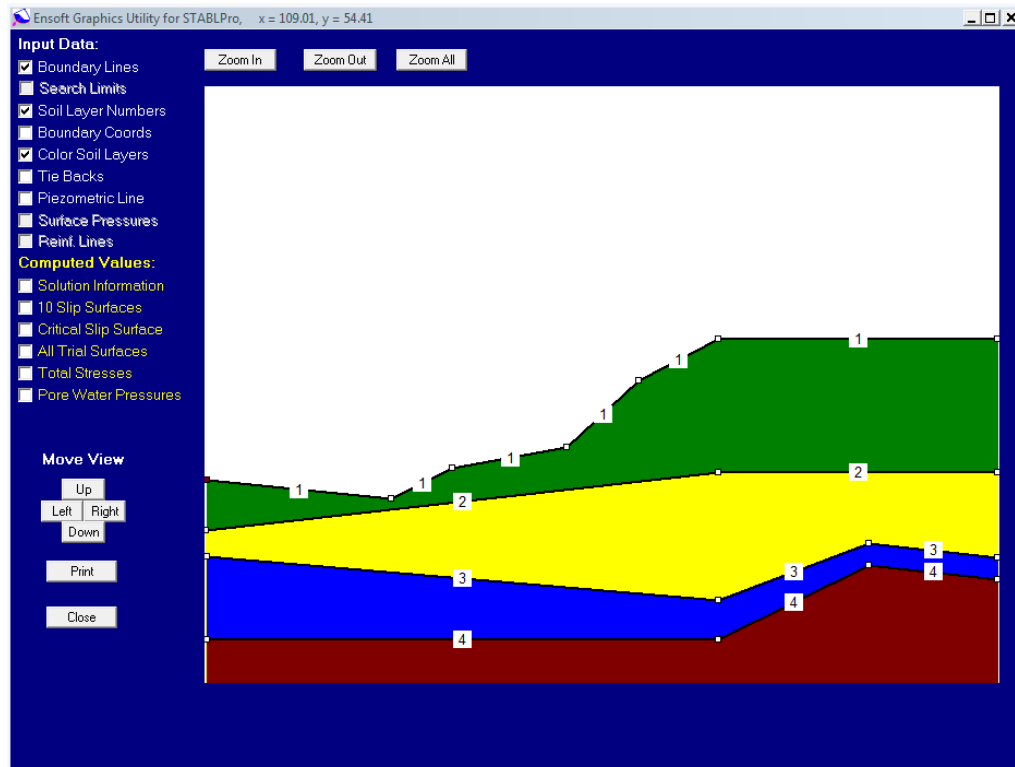


Figure 4.6 Graphics presentation for soil layers in color.

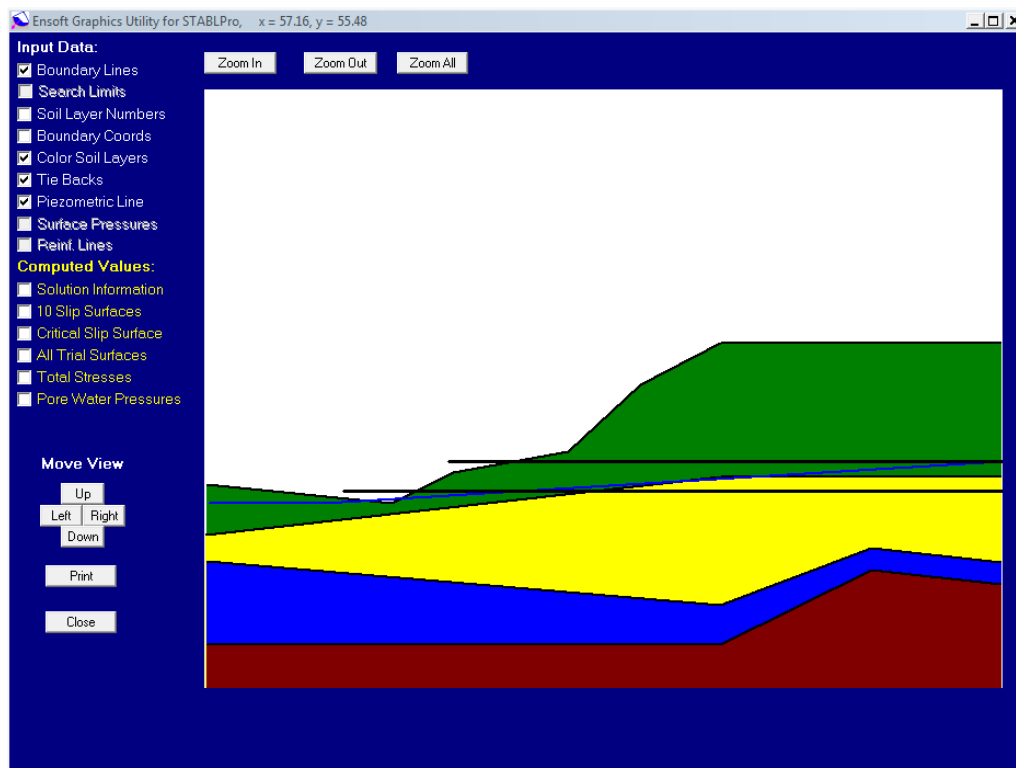


Figure 4.7 Graphics presentation for Tiebacks and Piezometric lines.

## Surface Pressures

The user may select this check-box 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 Fig. 4.8.

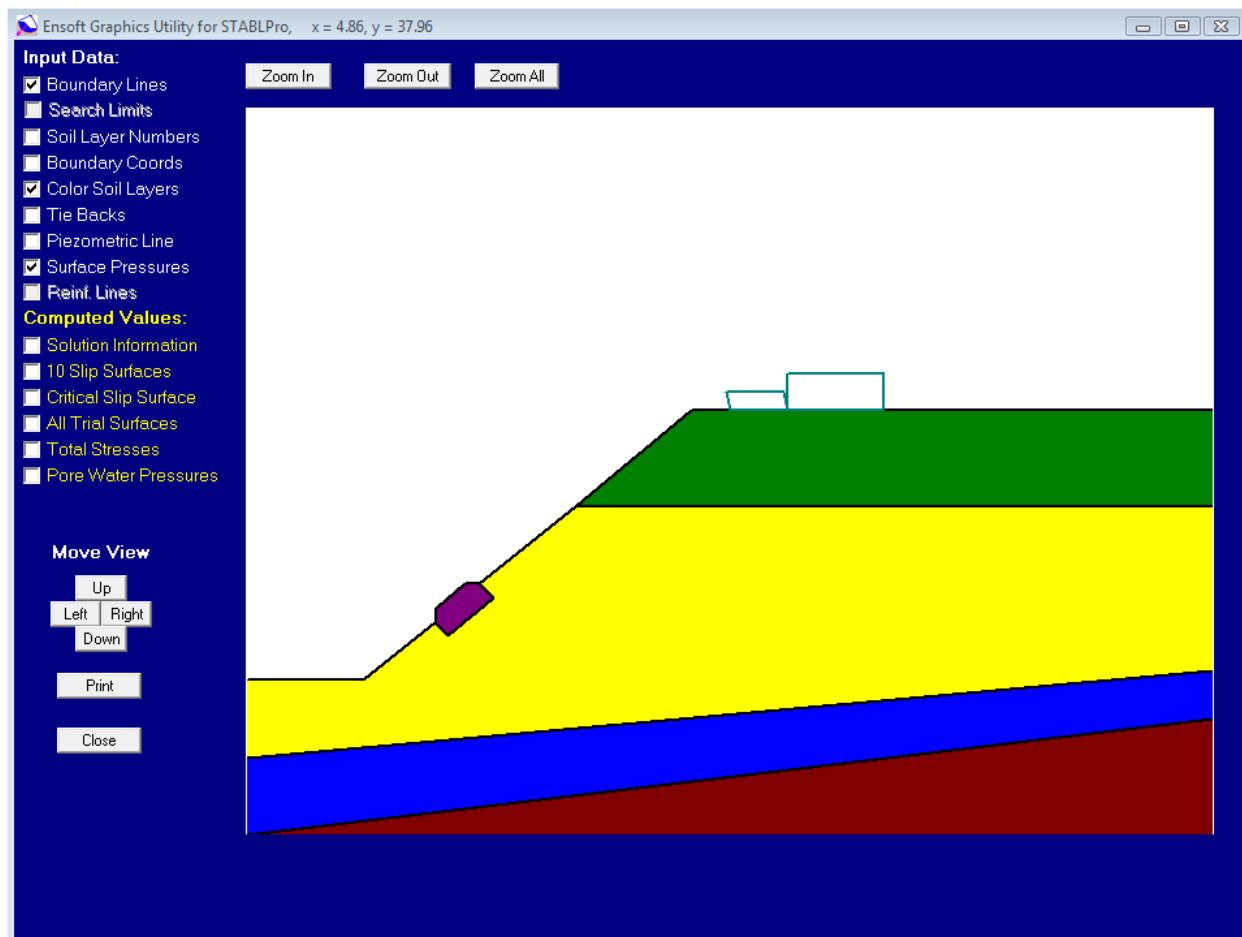


Figure 4.8 Graphics presentation for Surface Pressure (Surcharge Load).

## Reinforce Lines

The user may select this check-box option to observe a graphical representation of reinforce layers within the slope geometry and soil layers as shown in Fig. 4.9.

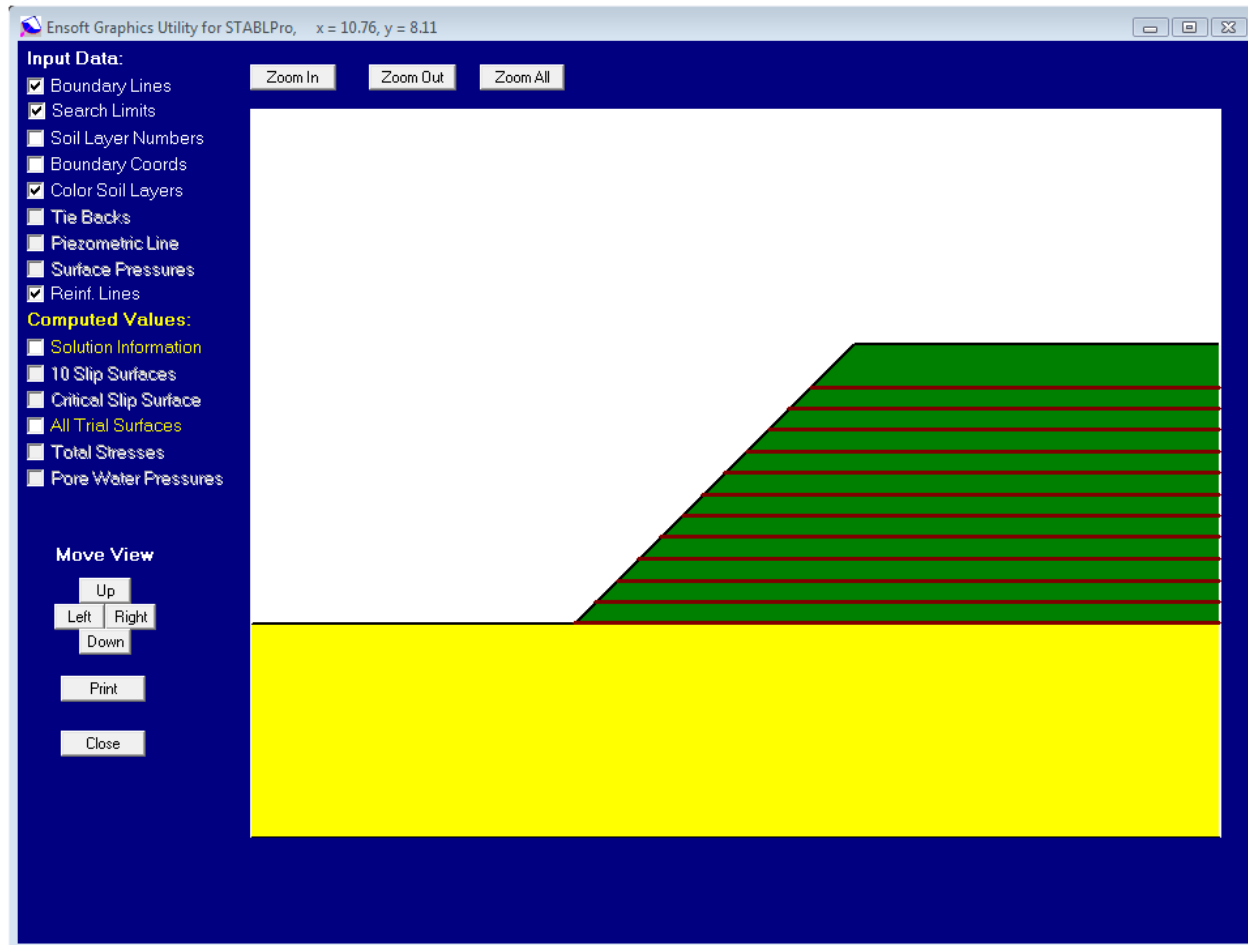


Figure 4.9 Graphics presentation for Reinforce Earth Layers

## Solution Information

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

## 10 Critical Slip Surfaces

The user may select this check-box option to observe the 10 most-critical slip surfaces within the slope boundaries as shown in Fig. 4.10.

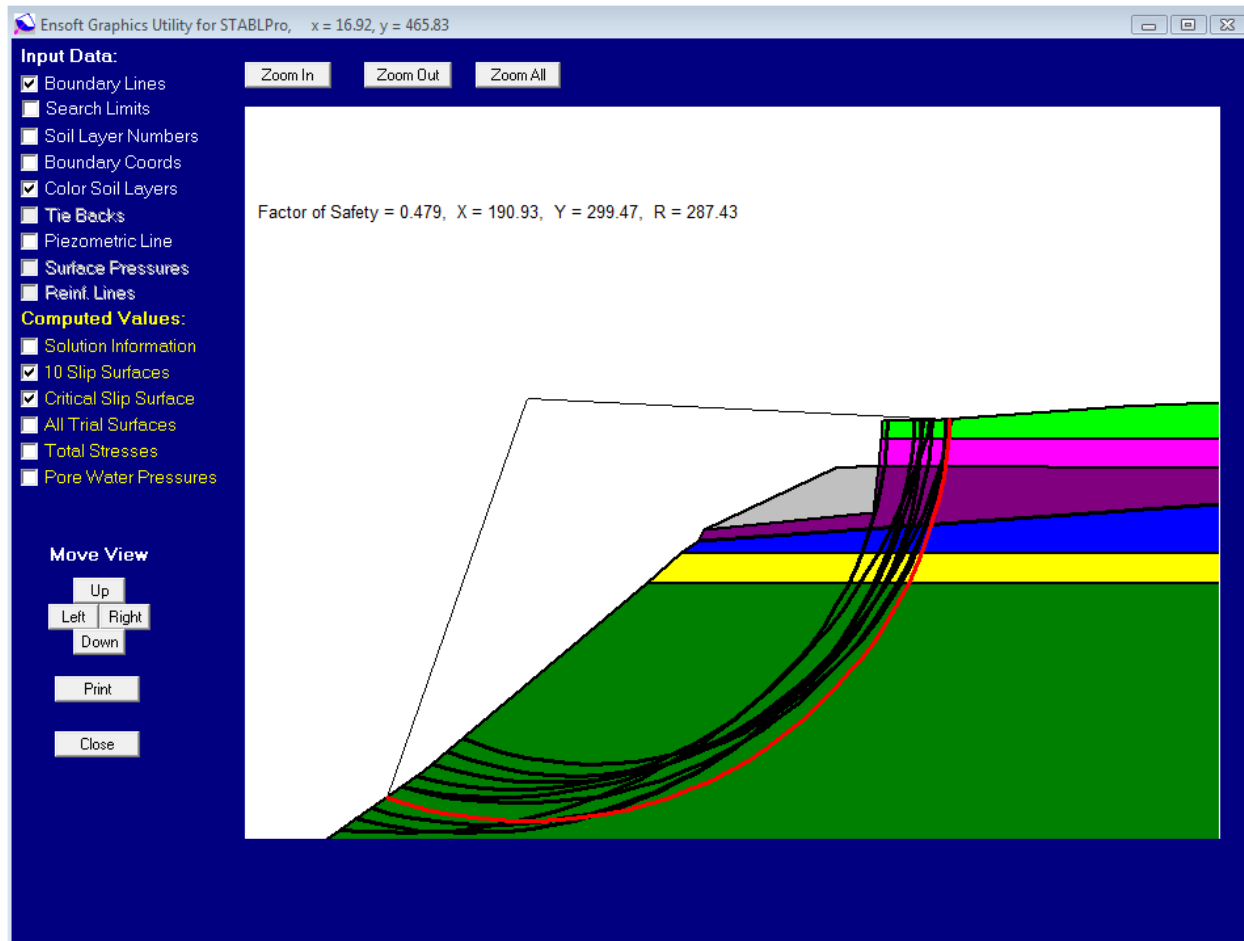


Figure 4.10 Graphics presentation for 10 critical slip surfaces

### 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 Fig. 4.11.

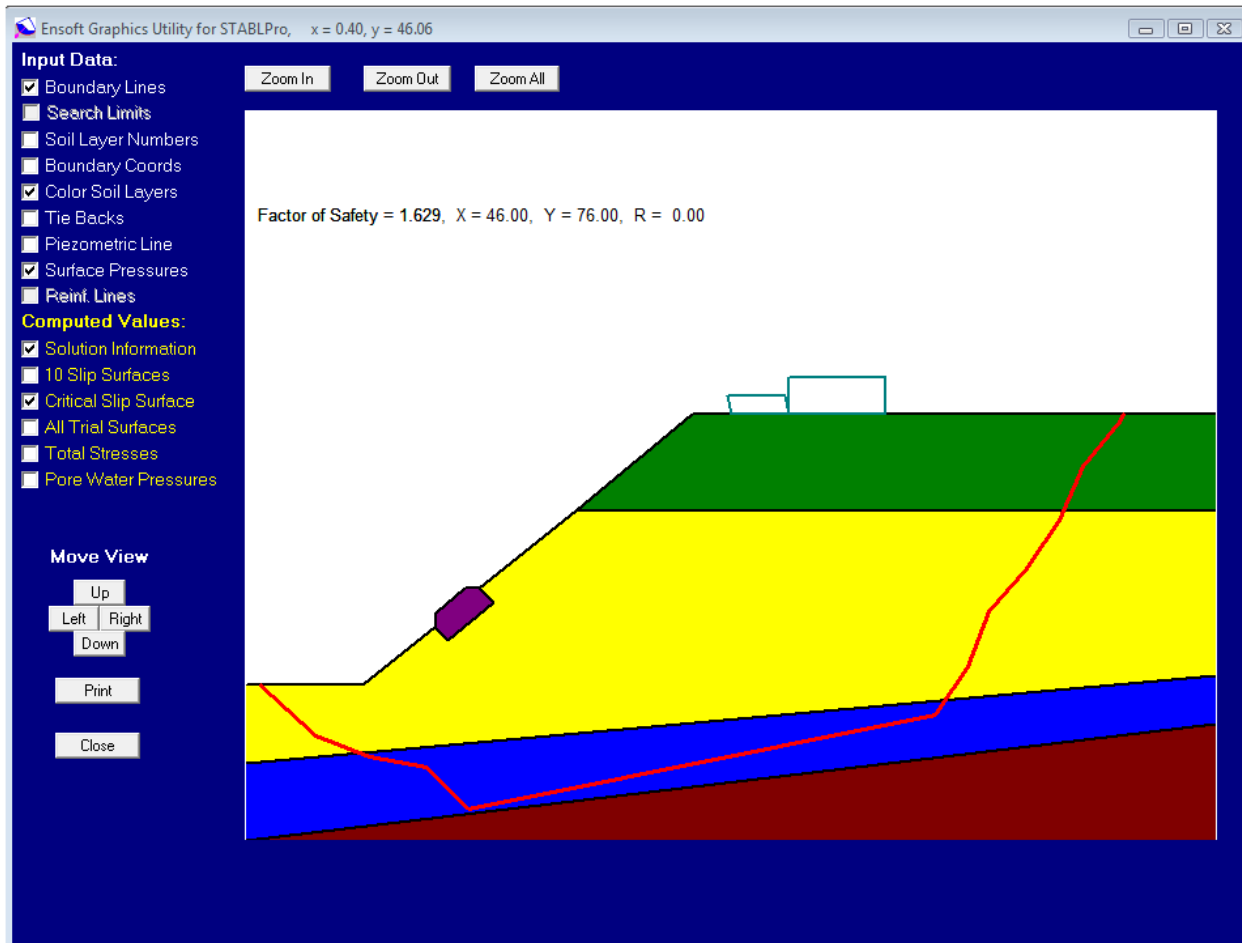


Figure 4.11 Graphics presentation for the most critical slip surface

### 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 Fig. 4.12.

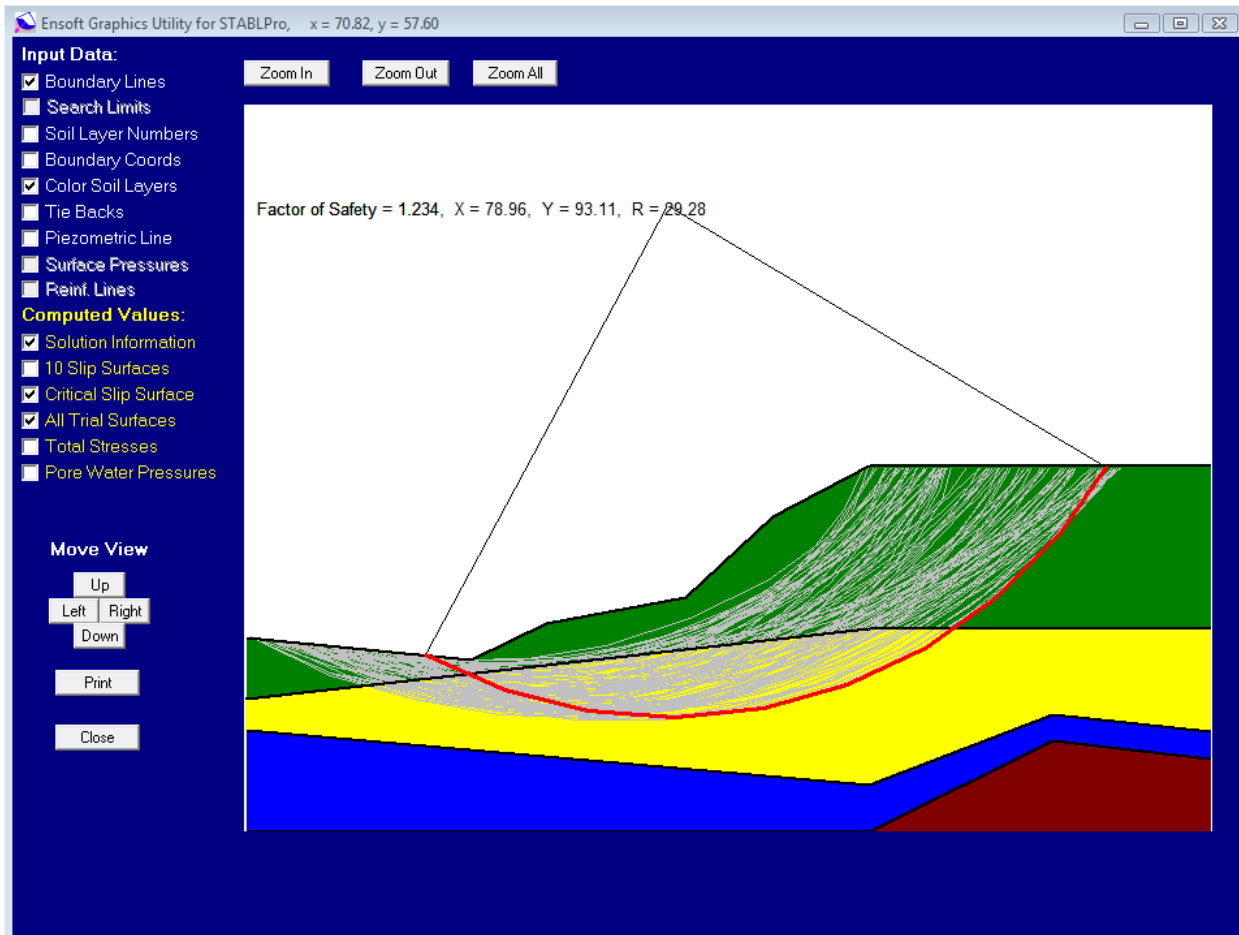


Figure 4.12 Graphics presentation for all trial slip surfaces



### 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 Fig. 4.13.

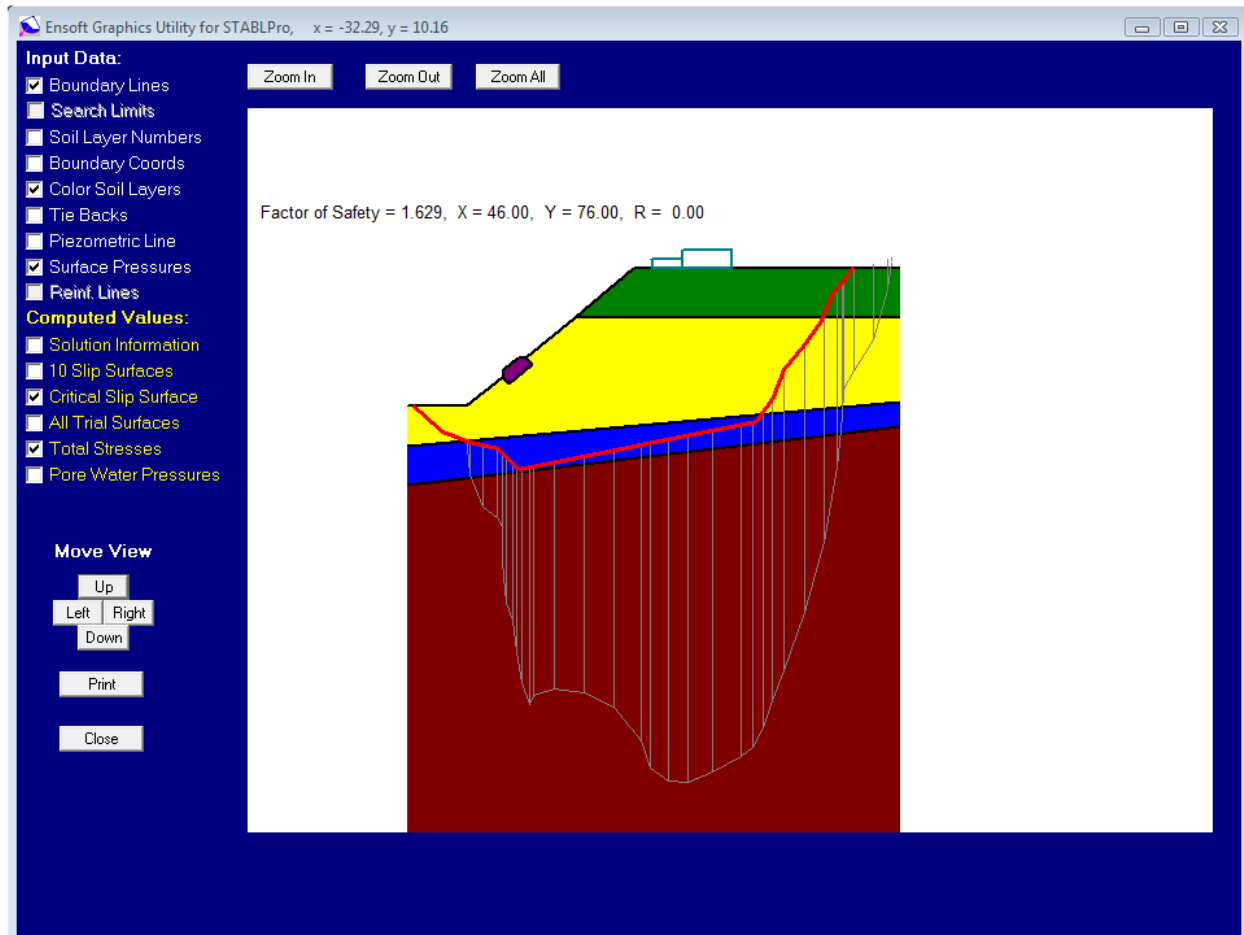


Figure 4.13 Graphics presentation for the total vertical stresses

### Pore Water Pressure

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

## **CHAPTER 5. Example Problems**

## 5.1 Introduction

This chapter presents several examples that were solved using STABLPRO. In order to assure 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 STABLPRO Technical Manual. The users can have confidence in their results if limited amounts of hand calculations can be done for comparisons. The studies in this chapter also provide guidance for the analysis of axially loaded piles with STABLPRO.

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 of the data are saved with 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 STABLPRO. Each example focuses on a particular computational feature of the program. Input files for each example are automatically copied to the STABLPRO data directory during installation (*<Root Drive>\Ensoft\STABLPRO2015-Examples*).

Example problems provide the user information on 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 STABLPRO.

The main features of each example included with STABLPRO 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 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.

## 5.2 Example Problem 1 (English Units)

The example concerns the long term stability of a cut in a soft clay material (Fig. 8.2). 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,  $\phi = 14$  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,  $\phi = 14$  deg. ). The clay within the tension zone is soil type number 2, which has the zero shear parameters ( $c' = 0$  psf,  $\phi = 0$  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. Generation of trial failure surfaces which pass through the bedrock is thus prevented.

The Bishop method will be used for the slope-stability analysis. Searching for the critical surface will be carried out within 100 trial failure surfaces generated by the program. Only the ten most-critical failure surfaces will be reported in the output. The input data and output results are given in the following pages for reference.

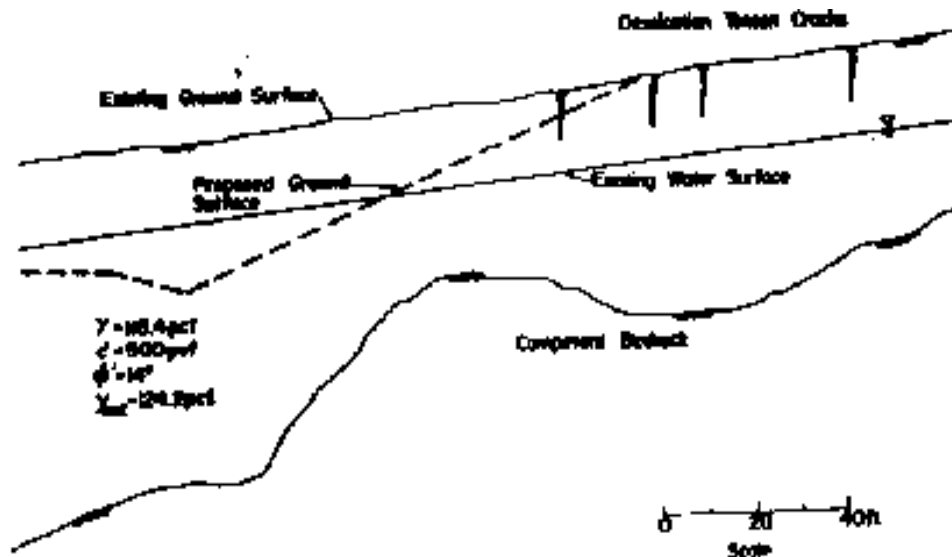


Figure 5.1 General soil description of Example Problem 1.

### 5.2.1 Input Data for Computer Analysis

The contents of the input-data file prepared for Example Problem 1 is reproduced below in courier typeface, for distinction.

```
PCSTABL6 Example #1
6 5 1
0. 68. 22. 67. 1
22. 67. 38. 63. 1
38. 63. 101. 88. 1
101. 88. 138. 103. 2
138. 103. 205. 110. 2
101. 88. 205. 99. 1
SOIL
2
116.4 124.2 500. 14. 0. 0. 1
116.4 116.4 0. 0. 0. 0. 1
WATERWATER
1 62.4
9
0. 68.
22. 67.
38. 63.
63. 73.
83. 78.
104. 82.
122. 85.
140. 87.
205. 93.
LIMITS
8 8
0. 15. 29. 24.
29. 24. 51. 26.
51. 26. 78. 56.
78. 56. 94. 65.
94. 65. 113. 64.
113. 64. 133. 56.
133. 56. 161. 58.
161. 58. 205. 76.
CIRCL2
5 25
38. 50. 138. 170.
0. 10. 0. -25.
EXECUT
```

### 5.2.2 Output Data

Contents of the output-data file for Example Problem 1 is reproduced below in courier typeface, for distinction.

```

1
** STABLPro V4.0**

Upgraded from
FHWA-PCSTABLE

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

Run Date:  
Time of Run:  
Run By:  
Input Data Filename:  
Output Filename:  
Plotted Output Filename:

PROBLEM DESCRIPTION PCSTABL6 Example #1

#### BOUNDARY COORDINATES

5 Top Boundaries  
6 Total Boundaries

Boundary No.	X-Left ft.	Y-Left ft.	X-Right ft.	Y-Right ft.	Soil Type Below Bnd
1	0.00	68.00	22.00	67.00	1
2	22.00	67.00	38.00	63.00	1
3	38.00	63.00	101.00	88.00	1
4	101.00	88.00	138.00	103.00	2
5	138.00	103.00	205.00	110.00	2
6	101.00	88.00	205.00	99.00	1

1

#### ISOTROPIC SOIL PARAMETERS

2 Type(s) of Soil

Soil Type No.	Total Unit Wt. pcf	Saturated Unit Wt. pcf	Cohesion Intercept psf	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant psf	Piez. Surface No.
1	116.4	124.2	500.0	14.0	0.00	0.0	1
2	116.4	116.4	0.0	0.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40 pcf

Piezometric Surface No. 1 Specified by 9 Coordinate Points

Point No.	X-Water ft.	Y-Water ft.
-----------	-------------	-------------

1	0.00	68.00
2	22.00	67.00
3	38.00	63.00
4	63.00	73.00
5	83.00	78.00
6	104.00	82.00
7	122.00	85.00
8	140.00	87.00
9	205.00	93.00

1

Searching Routine Will Be Limited To An Area Defined By 8 Boundaries  
Of Which The First 8 Boundaries Will Deflect Surfaces Upward

Boundary No.	X-Left ft.	Y-Left ft.	X-Right ft.	Y-Right ft.
1	0.00	15.00	29.00	24.00
2	29.00	24.00	51.00	26.00
3	51.00	26.00	78.00	56.00
4	78.00	56.00	94.00	65.00
5	94.00	65.00	113.00	64.00
6	113.00	64.00	133.00	56.00
7	133.00	56.00	161.00	58.00
8	161.00	58.00	205.00	76.00

1

A Critical Failure Surface Searching Method, Using A Random  
Technique For Generating Circular Surfaces, Has Been Specified.

125 Trial Surfaces Have Been Generated.

25 Surfaces Initiate From Each Of 5 Points Equally Spaced  
Along The Ground Surface Between X = 38.00 ft.  
and X = 50.00 ft.

Each Surface Terminates Between X = 138.00 ft.  
and X = 170.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation  
At Which A Surface Extends Is Y = 0.00 ft.

10.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation.  
The Angle Has Been Restricted Between The Angles Of -25.0  
And 0.0 deg.

1

Following Are Displayed The Ten Most Critical Of The Trial  
Failure Surfaces Examined. They Are Ordered - Most Critical  
First.

\* \* Safety Factors Are Calculated By The Modified Bishop Method \* \*

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	41.00	64.19
2	50.81	62.27
3	60.77	61.30
4	70.77	61.27
5	80.72	62.20
6	90.55	64.08
7	100.14	66.89
8	109.43	70.60
9	118.32	75.17
10	126.74	80.58
11	134.60	86.76
12	141.83	93.66
13	148.38	101.22
14	150.57	104.31

Circle Center At X = 66.0 ; Y = 165.9 and Radius, 104.7

\*\*\* 1.372 \*\*\*

Individual data on the 21 slices

Slice No.	Width Ft	Weight Lbs	Water		Tie Force Norm Lbs	Tie Force Tan Lbs	Earthquake		Surcharge Load Lbs
			Force Top Lbs	Force Bot Lbs			Force Hor Lbs	Force Ver Lbs	
1	9.8	0.35E+04	0.17E+02	0.18E+04	0.00E+00	0.0	0.0	0.0	0.0
2	10.0	0.10E+05	0.38E+02	0.52E+04	0.00E+00	0.0	0.0	0.0	0.0
3	2.2	0.31E+04	0.11E+02	0.16E+04	0.00E+00	0.0	0.0	0.0	0.0
4	7.8	0.13E+05	0.00E+00	0.61E+04	0.00E+00	0.0	0.0	0.0	0.0
5	10.0	0.20E+05	0.00E+00	0.90E+04	0.00E+00	0.0	0.0	0.0	0.0
6	2.3	0.50E+04	0.00E+00	0.22E+04	0.00E+00	0.0	0.0	0.0	0.0
7	7.5	0.18E+05	0.00E+00	0.74E+04	0.00E+00	0.0	0.0	0.0	0.0
8	9.6	0.24E+05	0.00E+00	0.93E+04	0.00E+00	0.0	0.0	0.0	0.0
9	0.9	0.22E+04	0.00E+00	0.82E+03	0.00E+00	0.0	0.0	0.0	0.0
10	3.0	0.76E+04	0.00E+00	0.28E+04	0.00E+00	0.0	0.0	0.0	0.0
11	5.4	0.14E+05	0.00E+00	0.47E+04	0.00E+00	0.0	0.0	0.0	0.0
12	8.9	0.22E+05	0.00E+00	0.67E+04	0.00E+00	0.0	0.0	0.0	0.0
13	3.7	0.86E+04	0.00E+00	0.23E+04	0.00E+00	0.0	0.0	0.0	0.0
14	4.7	0.10E+05	0.00E+00	0.22E+04	0.00E+00	0.0	0.0	0.0	0.0
15	7.3	0.14E+05	0.00E+00	0.14E+04	0.00E+00	0.0	0.0	0.0	0.0
16	0.5	0.92E+03	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
17	3.4	0.55E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
18	2.3	0.32E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
19	1.6	0.19E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
20	6.5	0.48E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
21	2.2	0.37E+03	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0



Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	38.00	63.00
2	47.91	61.64
3	57.89	61.08
4	67.89	61.32
5	77.83	62.36
6	87.67	64.19
7	97.32	66.80
8	106.73	70.18
9	115.84	74.30
10	124.59	79.14
11	132.93	84.66
12	140.80	90.84
13	148.15	97.62
14	154.72	104.75

Circle Center At X = 59.9 ; Y = 185.8 and Radius, 124.8

\*\*\* 1.374 \*\*\*

1

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	41.00	64.19
2	50.86	62.53
3	60.83	61.72
4	70.83	61.76
5	80.79	62.67
6	90.63	64.42
7	100.29	67.00
8	109.70	70.41
9	118.77	74.61
10	127.46	79.57
11	135.68	85.25
12	143.39	91.62
13	150.53	98.62
14	155.89	104.87

Circle Center At X = 65.3 ; Y = 178.3 and Radius, 116.7

\*\*\* 1.374 \*\*\*

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
--------------	---------------	---------------

1	38.00	63.00
2	47.80	60.99
3	57.74	59.98
4	67.74	59.99
5	77.69	61.02
6	87.48	63.05
7	97.02	66.07
8	106.19	70.04
9	114.92	74.93
10	123.10	80.67
11	130.66	87.22
12	137.51	94.51
13	143.58	102.45
14	144.33	103.66

Circle Center At X = 62.6 ; Y = 158.0 and Radius, 98.2

\*\*\* 1.374 \*\*\*

1

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	41.00	64.19
2	50.89	62.72
3	60.87	62.01
4	70.87	62.06
5	80.83	62.89
6	90.71	64.47
7	100.43	66.81
8	109.94	69.88
9	119.19	73.68
10	128.13	78.18
11	136.69	83.34
12	144.83	89.15
13	152.50	95.57
14	159.66	102.55
15	162.28	105.54

Circle Center At X = 65.1 ; Y = 192.2 and Radius, 130.3

\*\*\* 1.377 \*\*\*

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	38.00	63.00
2	47.84	61.23
3	57.81	60.40
4	67.81	60.53

5	77.75	61.62
6	87.54	63.65
7	97.09	66.62
8	106.31	70.48
9	115.13	75.20
10	123.45	80.75
11	131.20	87.07
12	138.31	94.10
13	144.71	101.78
14	146.13	103.85

Circle Center At X = 61.4 ; Y = 164.7 and Radius, 104.4

\*\*\* 1.378 \*\*\*

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	38.00	63.00
2	47.94	61.95
3	57.94	61.54
4	67.93	61.77
5	77.89	62.66
6	87.78	64.18
7	97.54	66.34
8	107.14	69.13
9	116.55	72.53
10	125.71	76.54
11	134.60	81.12
12	143.17	86.28
13	151.39	91.97
14	159.22	98.19
15	166.64	104.90
16	167.82	106.12

Circle Center At X = 59.3 ; Y = 216.1 and Radius, 154.6

\*\*\* 1.384 \*\*\*

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	41.00	64.19
2	50.89	62.68
3	60.86	62.00
4	70.86	62.15
5	80.81	63.14
6	90.65	64.95
7	100.30	67.58
8	109.69	71.00

9	118.77	75.19
10	127.47	80.13
11	135.72	85.78
12	143.48	92.09
13	150.68	99.03
14	155.80	104.86

Circle Center At X = 64.0 ; Y = 181.8 and Radius, 119.8

\*\*\* 1.386 \*\*\*

1

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	44.00	65.38
2	53.82	63.48
3	63.77	62.50
4	73.77	62.44
5	83.73	63.30
6	93.57	65.07
7	103.21	67.74
8	112.56	71.29
9	121.54	75.69
10	130.08	80.89
11	138.11	86.86
12	145.54	93.54
13	152.34	100.88
14	155.35	104.81

Circle Center At X = 69.5 ; Y = 170.8 and Radius, 108.4

\*\*\* 1.387 \*\*\*

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	41.00	64.19
2	50.91	62.87
3	60.90	62.32
4	70.90	62.53
5	80.85	63.52
6	90.69	65.27
7	100.37	67.77
8	109.84	71.01
9	119.02	74.97
10	127.87	79.62
11	136.34	84.94
12	144.37	90.90
13	151.92	97.46
14	158.94	104.58

15                      159.51                      105.25

Circle Center At X = 63.1 ; Y = 192.1 and Radius, 129.8

\*\*\*                      1.393                      \*\*\*

### 5.2.3 Graphical Results of Computer Analysis

The critical failure surface was marked in red and the factor of safety is 1.372. It is very useful for the user to plot another 10 most-critical slip surfaces, or all trial surfaces together for comparison as shown in **Error! Reference source not found.**

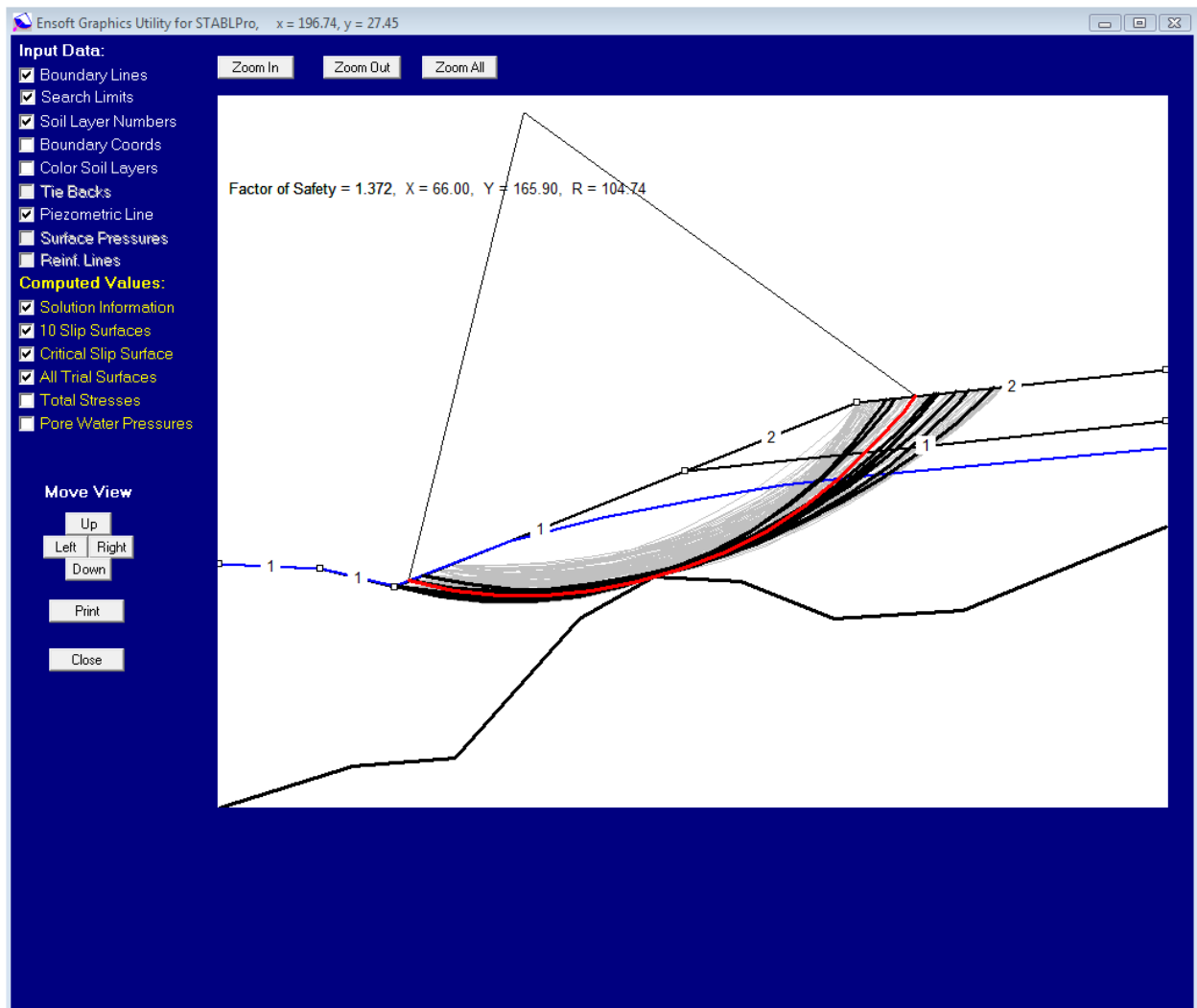


Figure 5.2 Plot of the most critical failure surface and other trial surfaces of Example Problem 1.

The use may add the distribution curves of the total normal stress as well as the pore water pressure in the same plot for study as shown in Figure 5.3.

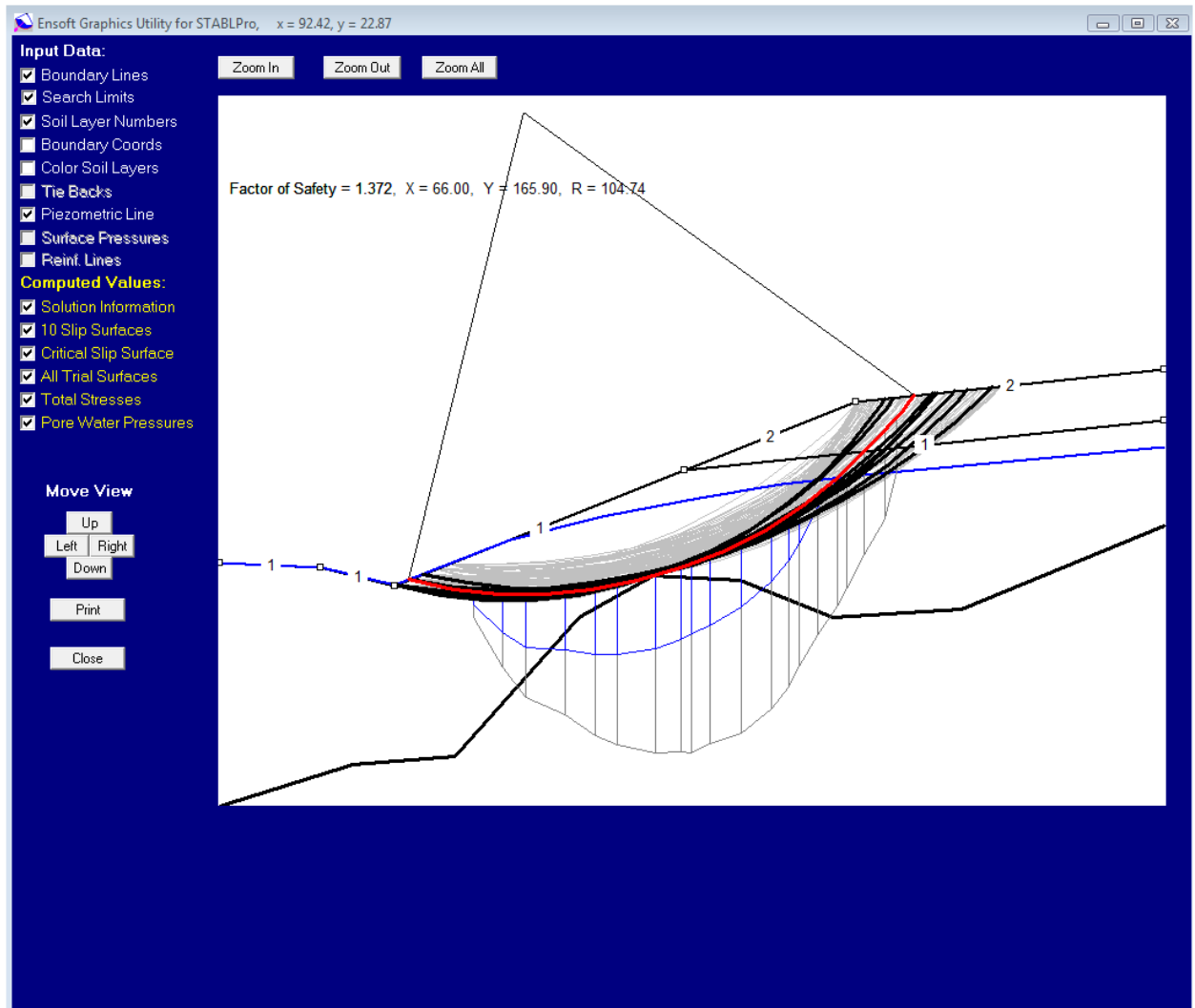


Figure 5.3 Plot of the most critical failure surface and the distribution of stresses of Example Problem 1.

### 5.3 Example Problem 2 (SI Units)

The profile shown in Fig. 5.4 represents a proposed excavation in a silty sand 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.

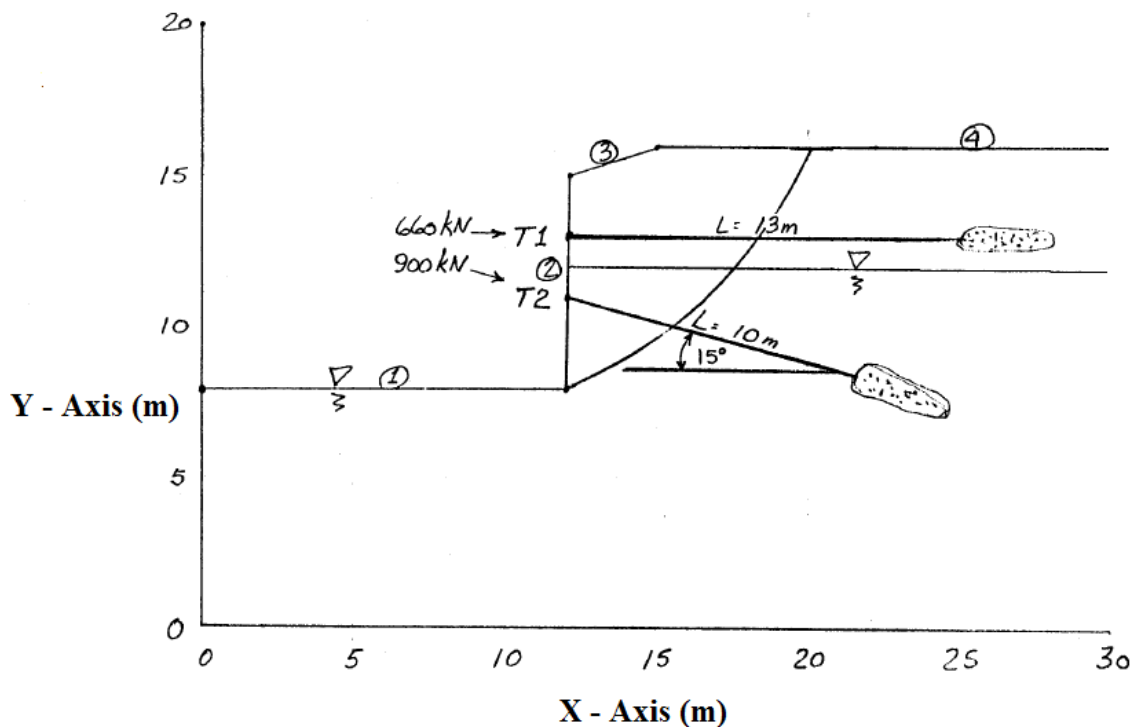


Figure 5.4 General soil description of Example Problem 2.

### 5.3.1 Input Data for Computer Analysis

The contents of the input-data file prepared for Example Problem 2 is reproduced below in courier typeface, for distinction.

```
PROFIL
Example 2 with tieback
4 4 2
0. 8. 12. 8. 1
12. 8. 12.1 15. 1
12.1 15. 15. 16. 1
15. 16. 30. 16. 1
SOIL
1
19.63 20.41 4.79 28. 0. 0. 1
WATER
1 9.81
4
0. 8.
12. 8.
12.05 12.
30. 12.
TIES
2
2 0. 13. 660. 10. 0. 13.
2 0. 11. 900. 10. 15. 10.
SURFAC
8
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.
EXECUT
```

### 5.3.2 Output Data

Contents of the output-data file for Example Problem 2 is reproduced below in courier typeface, for distinction.

```

** STABLPro V4.0**

Upgraded from
FHWA-PCSTABLE

1

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

Run Date:
Time of Run:
Run By:
Input Data Filename:
Output Filename:
```



Plotted Output Filename:

PROBLEM DESCRIPTION Example 2 with tieback

BOUNDARY COORDINATES

4 Top Boundaries  
4 Total Boundaries

Boundary No.	X-Left M	Y-Left M	X-Right M	Y-Right M	Soil Type Below Bnd
1	0.00	8.00	12.00	8.00	1
2	12.00	8.00	12.10	15.00	1
3	12.10	15.00	15.00	16.00	1
4	15.00	16.00	30.00	16.00	1

1

ISOTROPIC SOIL PARAMETERS

1 Type(s) of Soil

Soil Type No.	Total Unit Wt. kN/M <sup>3</sup>	Saturated Unit Wt. kN/M <sup>3</sup>	Cohesion Intercept kPa	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant kPa	Piez. Surface No.
1	19.6	20.4	4.8	28.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 9.81 kN/M<sup>3</sup>

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water M	Y-Water M
1	0.00	8.00
2	12.00	8.00
3	12.05	12.00
4	30.00	12.00

1

TIEBACK LOAD(S)

2 Tieback Load(s) Specified

Tieback No.	X-Pos M	Y-Pos M	Load KN	Spacing M	Inclination (deg)	Length M
1	12.07	13.00	660.0	10.0	0.00	13.0
2	12.04	11.00	900.0	10.0	15.00	10.0

NOTE - An Equivalent Line Load Is Calculated For Each Row Of Tiebacks  
Assuming A Uniform Distribution Of Load Horizontally Between  
Individual Tiebacks.

1

Trial Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf M	Y-Surf M
1	12.00	8.00
2	13.80	8.90
3	15.50	10.00
4	17.00	11.30
5	18.50	12.65
6	19.75	14.20
7	20.90	15.80
8	21.00	16.00

Factor Of Safety For The Preceding Specified Surface = 1.224

### 5.3.3 Graphical Results of Computer Analysis

The factor of safety for the same specified failure surface without tiebacks is 0.71. The factor of safety for the specified failure surface increases to 1.224 with the tieback as shown in Figure 5.5. There are several parameters related to tiebacks, which may alter the factor of safety. Those parameters include the tieback loads, the tieback spacing, and the free length of the tieback. It is very useful for the user to conduct some parametric studies for understanding those influences.

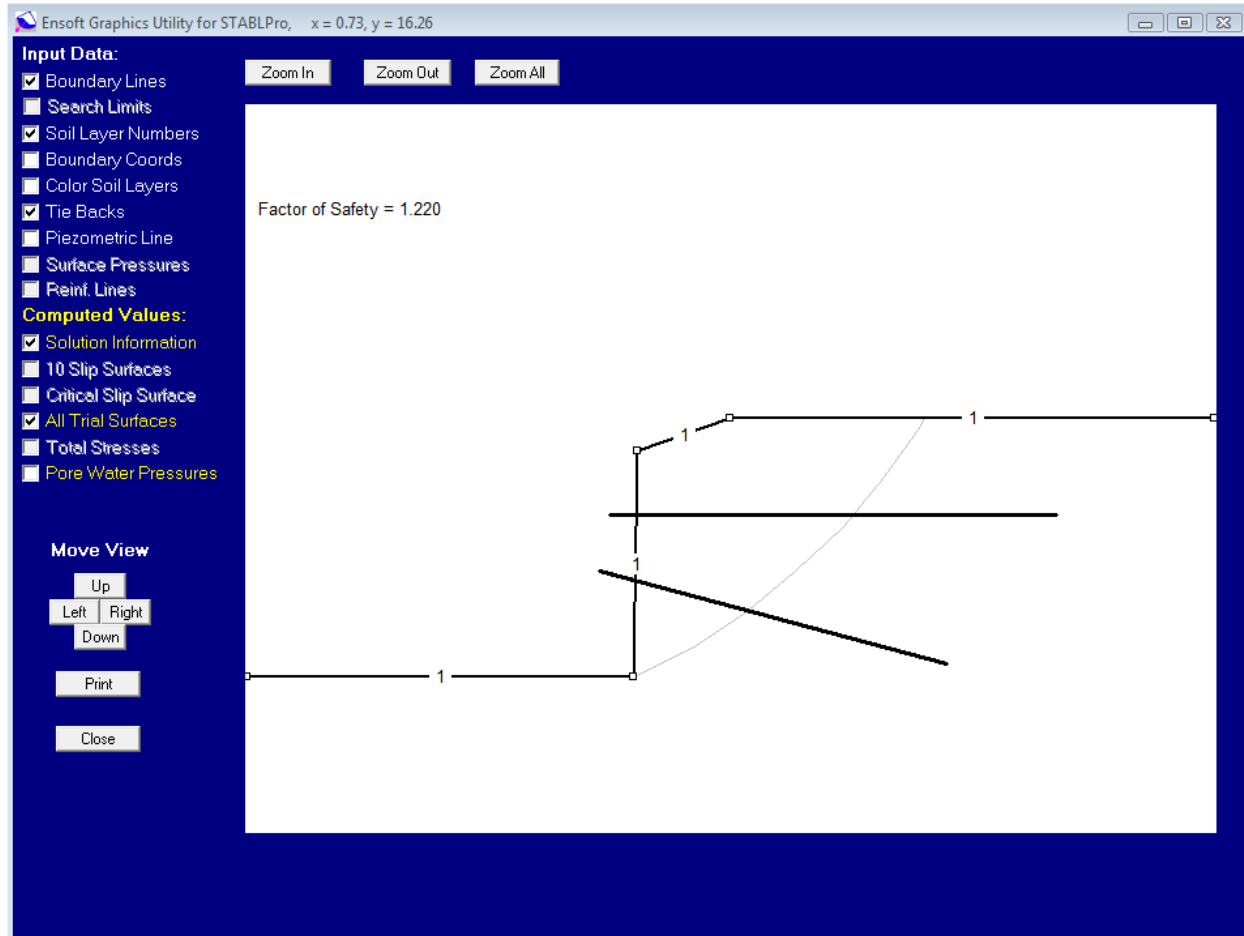


Figure 5.5 Plot of the failure surface with two tiebacks of Example Problem 2.

### 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 Fig. 5.6 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 is occurring. 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 by a 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 anchor into the bedrock. The anchors are placed at a horizontal spacing of 10 feet and are 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.

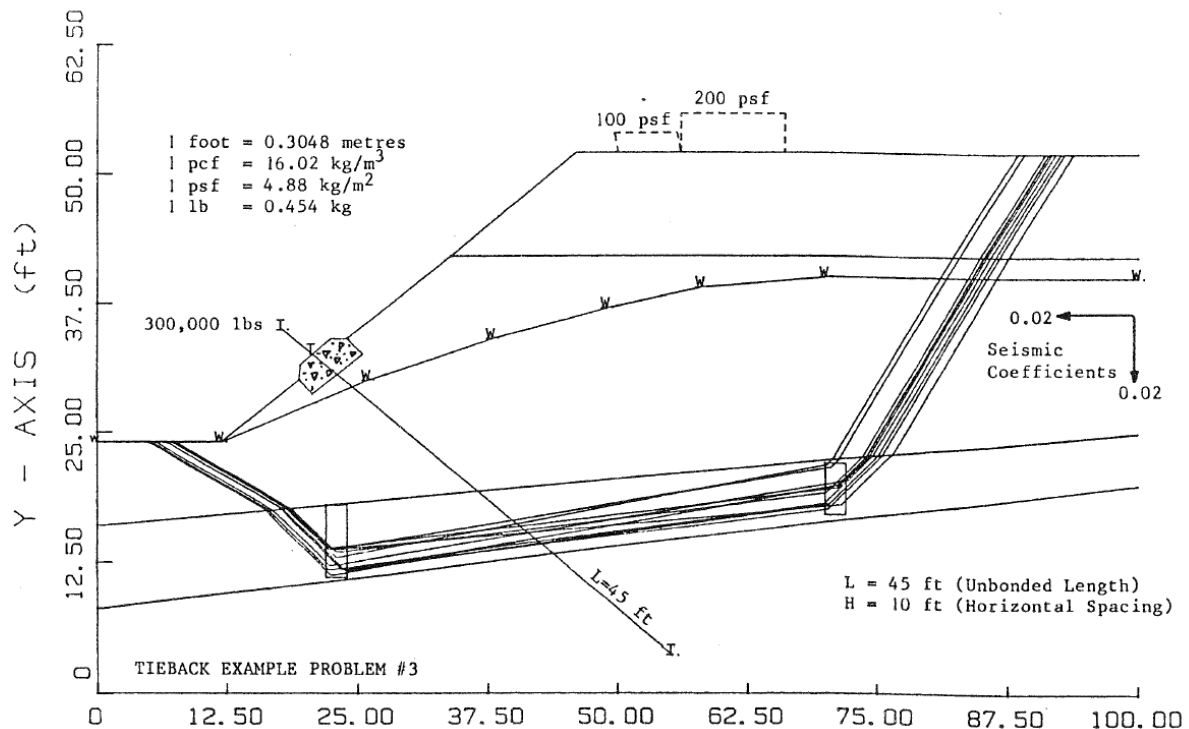


Figure 5.6 General soil description of Example Problem 3.

### 5.4.1 Input Data for Computer Analysis

The contents of the input-data file prepared for Example Problem 3 is reproduced below in courier typeface, for distinction.

```

PROFIL
TIEBACK EXAMPLE PROBLEM #3
14 8 1
0. 24. 12. 24. 2
12. 24. 19.5 30. 2
19.5 30. 19.6 31.5 5
19.6 31.5 22.5 34. 5
22.5 34. 24. 34. 5
24. 34. 34. 42. 2
34. 42. 46. 52. 1
46. 52. 100. 52. 1
34. 42. 100. 42. 2
24. 34. 25.5 32.5 5
19.5 30. 20.8 28.6 2
20.8 28.6 25.5 32.5 2
0. 16. 100. 25. 3
0. 8. 100. 20. 4
SOIL
5
120. 125. 400. 26. 0. 0. 1
122. 127. 850. 30. 0. 0. 1
115. 120. 475. 0. 0. 0. 1
144. 147. 0. 45. 0. 0. 1
150. 150. 0. 0. 0. 0. 1
ANISO
1
2 2
-30. 600. 34.
90. 300. 28.
WATER
1 62.4
8
0. 24.
12. 24.
26. 30.
38. 34.
49. 37.
58. 39.
70. 40.
100. 40.
LOADS
2
50. 56. 100. 10.
56. 66. 200. 0.
EQUAKE
0.02 0.02 0.00
TIES
1
4 0. 32.5 300000. 10. 40. 45.
BLOCK
25 2 6.
22. 14.5 24. 14.5 7.
70. 19.5 72. 19.5 5.
EXECUT

```

## 5.4.2 Output Data

Contents of the output-data file for Example Problem 3 is reproduced below in courier typeface, for distinction.

```

** STABLPro V4.0**

Upgraded from
FHWA-PCSTABLE

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

Run Date:
Time of Run:
Run By:
Input Data Filename:
Output Filename:

PROBLEM DESCRIPTION    TIEBACK EXAMPLE PROBLEM #3

BOUNDARY COORDINATES

    8 Top    Boundaries
    14 Total Boundaries

Boundary    X-Left    Y-Left    X-Right    Y-Right    Soil Type
No.         ft.       ft.       ft.       ft.       Below Bnd

    1         0.00     24.00     12.00     24.00         2
    2        12.00     24.00     19.50     30.00         2
    3        19.50     30.00     19.60     31.50         5
    4        19.60     31.50     22.50     34.00         5
    5        22.50     34.00     24.00     34.00         5
    6        24.00     34.00     34.00     42.00         2
    7        34.00     42.00     46.00     52.00         1
    8        46.00     52.00     100.00    52.00         1
    9        34.00     42.00     100.00    42.00         2
   10        24.00     34.00     25.50     32.50         5
   11        19.50     30.00     20.80     28.60         2
   12        20.80     28.60     25.50     32.50         2
   13         0.00     16.00     100.00    25.00         3
   14         0.00      8.00     100.00    20.00         4

ISOTROPIC SOIL PARAMETERS

    5 Type(s) of Soil

```

Soil Type No.	Total Unit Wt. pcf	Saturated Unit Wt. pcf	Cohesion Intercept psf	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant psf	Piez. Surface No.
1	120.0	125.0	400.0	26.0	0.00	0.0	1
2	122.0	127.0	850.0	30.0	0.00	0.0	1
3	115.0	120.0	475.0	0.0	0.00	0.0	1
4	144.0	147.0	0.0	45.0	0.00	0.0	1
5	150.0	150.0	0.0	0.0	0.00	0.0	1

## ANISOTROPIC STRENGTH PARAMETERS

1 soil type(s)

Soil Type 2 Is Anisotropic

Number Of Direction Ranges Specified = 2

Direction Range No.	Counterclockwise Direction Limit (deg)	Cohesion Intercept psf	Friction Angle (deg)
1	-30.0	600.0	34.0
2	90.0	300.0	28.0

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40 pcf

Piezometric Surface No. 1 Specified by 8 Coordinate Points

Point No.	X-Water ft.	Y-Water ft.
1	0.00	24.00
2	12.00	24.00
3	26.00	30.00
4	38.00	34.00
5	49.00	37.00
6	58.00	39.00
7	70.00	40.00
8	100.00	40.00

1

## BOUNDARY LOAD(S)

2 Load(s) Specified

Load No.	X-Left ft.	X-Right ft.	Intensity psf	Deflection (deg)
----------	------------	-------------	---------------	------------------

1	50.00	56.00	100.0	10.0
2	56.00	66.00	200.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed  
Force Acting On A Horizontally Projected Surface.

A Horizontal Earthquake Loading Coefficient  
Of 0.020 Has Been Assigned

A Vertical Earthquake Loading Coefficient  
Of 0.020 Has Been Assigned

Cavitation Pressure = 0.0 psf

1

TIEBACK LOAD(S)

1 Tieback Load(s) Specified

Tieback No.	X-Pos ft.	Y-Pos ft.	Load lbs	Spacing ft.	Inclination (deg)	Length ft.
1	20.76	32.50	300000.0	10.0	40.00	45.0

NOTE - An Equivalent Line Load Is Calculated For Each Row Of Tiebacks  
Assuming A Uniform Distribution Of Load Horizontally Between  
Individual Tiebacks.

1

A Critical Failure Surface Searching Method, Using A Random  
Technique For Generating Sliding Block Surfaces, Has Been  
Specified.

25 Trial Surfaces Have Been Generated.

2 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of  
Sliding Block Is 6.0

Box No.	X-Left ft.	Y-Left ft.	X-Right ft.	Y-Right ft.	Height ft.
1	22.00	14.50	24.00	14.50	7.00
2	70.00	19.50	72.00	19.50	5.00

1

Following Are Displayed The Ten Most Critical Of The Trial  
Failure Surfaces Examined. They Are Ordered - Most Critical



First.

\* \* Safety Factors Are Calculated By The Modified Janbu Method \* \*

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	1.55	24.00
2	2.77	22.84
3	7.13	18.72
4	12.76	16.64
5	18.64	15.46
6	22.90	11.24
7	71.19	21.02
8	74.55	25.99
9	76.58	31.63
10	80.62	36.07
11	83.85	41.13
12	86.37	46.57
13	90.15	51.23
14	90.45	52.00

\*\*\* 1.629 \*\*\*

Individual data on the 34 slices

Slice No.	Width Ft	Weight Lbs	Water		Tie		Earthquake		Surcharge Load Lbs
			Force Top Lbs	Force Bot Lbs	Force Norm Lbs	Force Tan Lbs	Force Hor Lbs	Force Ver Lbs	
1	1.2	0.89E+02	0.00E+00	0.61E+02	0.00E+00	0.0	1.8	1.8	0.0
2	4.4	0.18E+04	0.00E+00	0.12E+04	0.00E+00	0.0	35.6	35.6	0.0
3	4.5	0.35E+04	0.00E+00	0.18E+04	-0.13E+02	-13.1	70.2	70.2	0.0
4	0.3	0.31E+03	0.00E+00	0.16E+03	-0.47E+02	-47.0	6.2	6.2	0.0
5	0.8	0.72E+03	0.00E+00	0.37E+03	0.25E+02	25.1	14.4	14.4	0.0
6	5.9	0.81E+04	0.00E+00	0.36E+04	-0.21E+03	-211.0	161.1	161.1	0.0
7	0.9	0.16E+04	0.00E+00	0.91E+03	0.38E+03	379.5	31.4	31.4	0.0
8	0.1	0.20E+03	0.00E+00	0.11E+03	0.46E+02	46.5	4.1	4.1	0.0
9	1.2	0.28E+04	0.00E+00	0.14E+04	0.59E+03	590.6	55.8	55.8	0.0
10	1.7	0.46E+04	0.00E+00	0.23E+04	0.91E+03	912.6	91.4	91.4	0.0
11	0.4	0.12E+04	0.00E+00	0.61E+03	0.22E+03	224.1	23.3	23.3	0.0
12	1.1	0.32E+04	0.00E+00	0.12E+04	-0.43E+02	-43.4	63.5	63.5	0.0
13	1.5	0.43E+04	0.00E+00	0.17E+04	-0.94E+01	-9.4	86.6	86.6	0.0
14	0.5	0.15E+04	0.00E+00	0.58E+03	0.11E+02	11.0	29.2	29.2	0.0
15	8.0	0.26E+05	0.00E+00	0.95E+04	0.12E+04	1218.1	518.1	518.1	0.0
16	4.0	0.15E+05	0.00E+00	0.50E+04	0.12E+04	1198.6	295.1	295.1	0.0
17	8.0	0.33E+05	0.00E+00	0.10E+05	0.29E+04	2891.8	663.7	663.7	0.0
18	3.0	0.13E+05	0.00E+00	0.39E+04	0.11E+04	1090.9	265.1	265.1	0.0
19	1.0	0.44E+04	0.00E+00	0.13E+04	0.36E+03	357.3	87.4	87.4	0.0
20	6.0	0.26E+05	0.00E+00	0.79E+04	0.20E+04	2049.6	514.5	514.5	600.0
21	2.0	0.84E+04	0.00E+00	0.26E+04	0.64E+03	640.2	167.7	167.7	400.0
22	8.0	0.33E+05	0.00E+00	0.10E+05	0.23E+04	2338.3	651.3	651.3	1600.0
23	4.0	0.16E+05	0.00E+00	0.50E+04	0.10E+04	1044.3	313.9	313.9	0.0

24	1.2	0.46E+04	0.00E+00	0.14E+04	0.30E+03	295.1	91.6	91.6	0.0
25	1.0	0.38E+04	0.00E+00	0.20E+04	0.18E+03	175.4	75.1	75.1	0.0
26	2.4	0.81E+04	0.00E+00	0.41E+04	0.44E+03	442.5	162.6	162.6	0.0
27	2.0	0.58E+04	0.00E+00	0.42E+04	0.37E+03	373.9	116.8	116.8	0.0
28	4.0	0.90E+04	0.00E+00	0.23E+04	0.83E+03	825.6	179.5	179.5	0.0
29	2.5	0.42E+04	0.00E+00	0.57E+03	0.50E+03	503.4	84.9	84.9	0.0
30	0.7	0.99E+03	0.00E+00	0.00E+00	0.14E+03	141.7	19.8	19.8	0.0
31	0.4	0.51E+03	0.00E+00	0.00E+00	0.84E+02	83.9	10.1	10.1	0.0
32	2.1	0.20E+04	0.00E+00	0.00E+00	0.44E+03	435.2	39.3	39.3	0.0
33	3.8	0.14E+04	0.00E+00	0.00E+00	0.63E+03	626.1	28.1	28.1	0.0
34	0.3	0.14E+02	0.00E+00	0.00E+00	0.60E+02	59.6	0.3	0.3	0.0

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	2.62	24.00
2	3.38	23.30
3	7.90	19.36
4	13.67	17.71
5	19.51	16.33
6	23.92	12.26
7	70.78	21.78
8	73.93	26.89
9	77.80	31.48
10	80.90	36.61
11	83.19	42.16
12	87.43	46.41
13	89.72	51.95
14	89.75	52.00

\*\*\* 1.716 \*\*\*

1

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	5.95	24.00
2	8.39	21.83
3	12.73	17.68
4	18.26	15.37
5	23.45	12.34
6	70.13	21.63
7	74.12	26.11
8	75.22	32.01
9	78.08	37.28
10	79.41	43.13
11	82.09	48.50
12	85.18	52.00

\*\*\* 1.838 \*\*\*

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	9.01	24.00
2	9.46	23.64
3	13.71	19.41
4	18.55	15.87
5	22.85	11.68
6	71.40	21.22
7	74.46	26.38
8	75.85	32.21
9	79.15	37.23
10	80.69	43.03
11	84.08	47.97
12	88.10	52.00

\*\*\* 1.912 \*\*\*

1

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	8.24	24.00
2	9.55	22.90
3	14.30	19.23
4	18.80	15.26
5	23.19	11.17
6	70.87	20.35
7	73.11	25.92
8	74.48	31.76
9	78.51	36.19
10	82.76	40.44
11	84.19	46.26
12	85.70	52.00

\*\*\* 1.913 \*\*\*

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	3.31	24.00
2	6.76	22.34
3	11.11	18.21
4	16.89	16.58
5	22.69	15.08
6	70.99	20.51
7	72.93	26.19

8	74.01	32.09
9	78.25	36.34
10	81.32	41.50
11	85.35	45.94
12	88.45	51.08
13	89.22	52.00

\*\*\* 1.928 \*\*\*

1

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	1.21	24.00
2	1.57	23.65
3	7.46	22.48
4	11.78	18.31
5	17.51	16.55
6	23.20	14.66
7	70.98	19.27
8	72.76	25.00
9	74.00	30.87
10	77.71	35.59
11	81.47	40.26
12	85.47	44.74
13	89.25	49.39
14	90.11	52.00

\*\*\* 1.973 \*\*\*

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	3.22	24.00
2	6.80	20.96
3	12.75	20.21
4	17.04	16.01
5	22.99	15.20
6	70.02	20.28
7	73.35	25.27
8	77.13	29.93
9	78.25	35.83
10	82.46	40.10
11	86.70	44.34
12	90.91	48.61
13	92.66	52.00

\*\*\* 1.989 \*\*\*

1

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	6.85	24.00
2	7.82	23.38
3	12.46	19.58
4	16.85	15.49
5	22.17	12.72
6	70.46	17.95
7	74.45	22.43
8	78.67	26.71
9	78.99	32.70
10	81.62	38.09
11	83.45	43.81
12	86.06	49.21
13	86.84	52.00

\*\*\* 2.042 \*\*\*

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	12.27	24.22
2	13.41	23.24
3	17.68	19.02
4	22.25	15.14
5	70.58	18.20
6	74.39	22.83
7	78.58	27.13
8	82.82	31.37
9	86.68	35.97
10	88.62	41.64
11	92.58	46.15
12	96.80	50.42
13	98.36	52.00

\*\*\* 2.143 \*\*\*

### 5.4.3 Graphical Results of Computer Analysis

The factor of safety for the same specified failure surface without tiebacks is 1.113. The factor of safety for the specified failure surface increases to 1.629 with the tieback as shown in Figure 5.7.

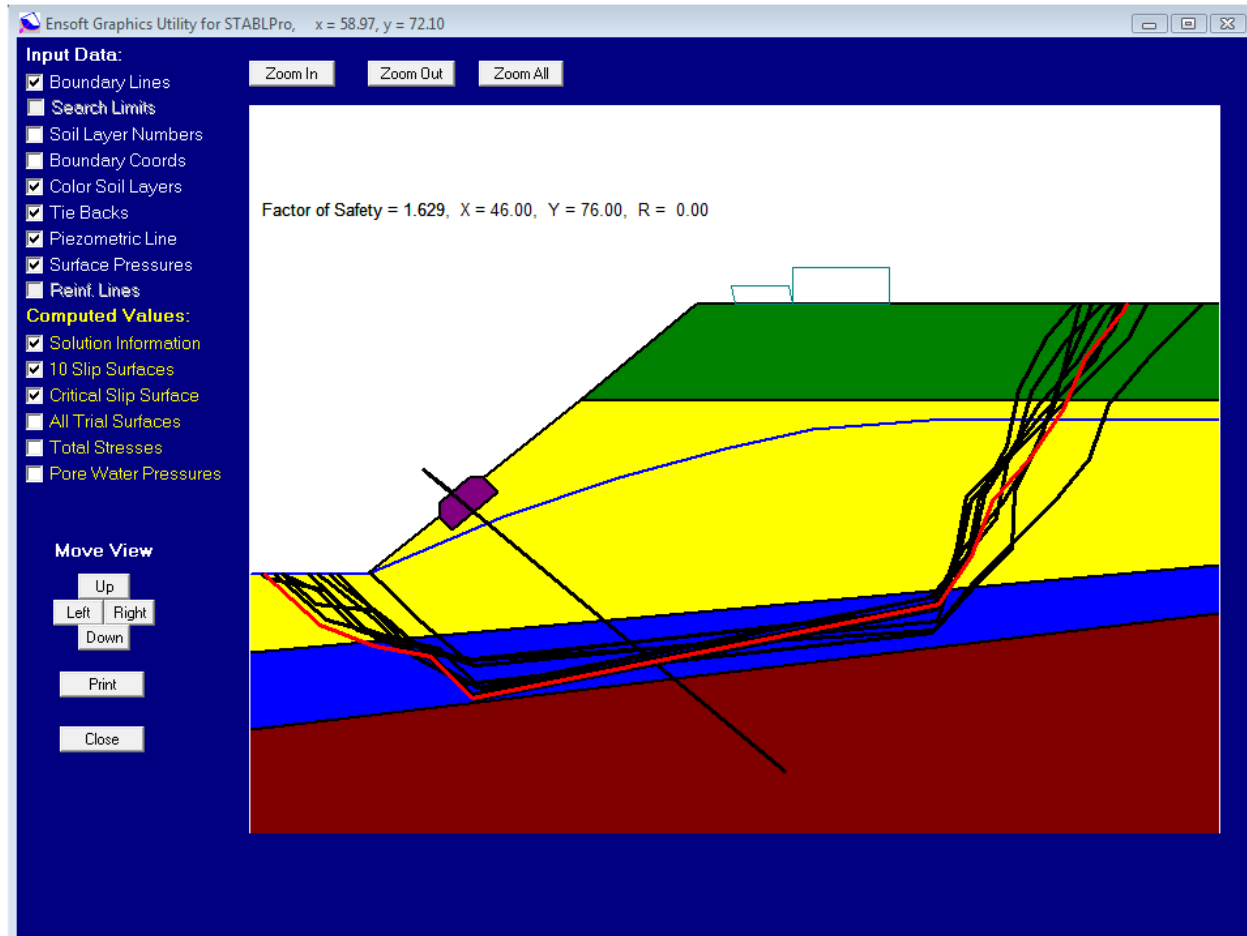


Figure 5.7 Plot of the block-failure surface with tiebacks of Example Problem 3.

## 5.5 Example Problem 4 (Reinforce 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 Fig. 5.8. The embankment soil has been arbitrarily assigned soil type number 1, which has the weak shear parameters ( $c' = 5.79$  kPa,  $\phi = 27$  deg, and  $\gamma = 19.63$  kN/m<sup>3</sup>). The foundation soil below the embankment is soil type number 2, which has little stronger shear parameters ( $c' = 9.58$  kPa,  $\phi = 30$  deg, and  $\gamma = 18.84$  kN/m<sup>3</sup>).

Tensile reinforcing layers provide a resisting moment which increases the embankment stability. This effect was incorporated into the simplified Bishop method. The methodology of 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, y coordinates starting at the left end of the reinforcement and moving to the right as indicated in Fig. 3.15. 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 is 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 specified that it acts normal to the slip surface. The Simplified Bishop method will be used for the slope-stability analysis either on the user-specified slip surface or the trial surfaces generated by the program.

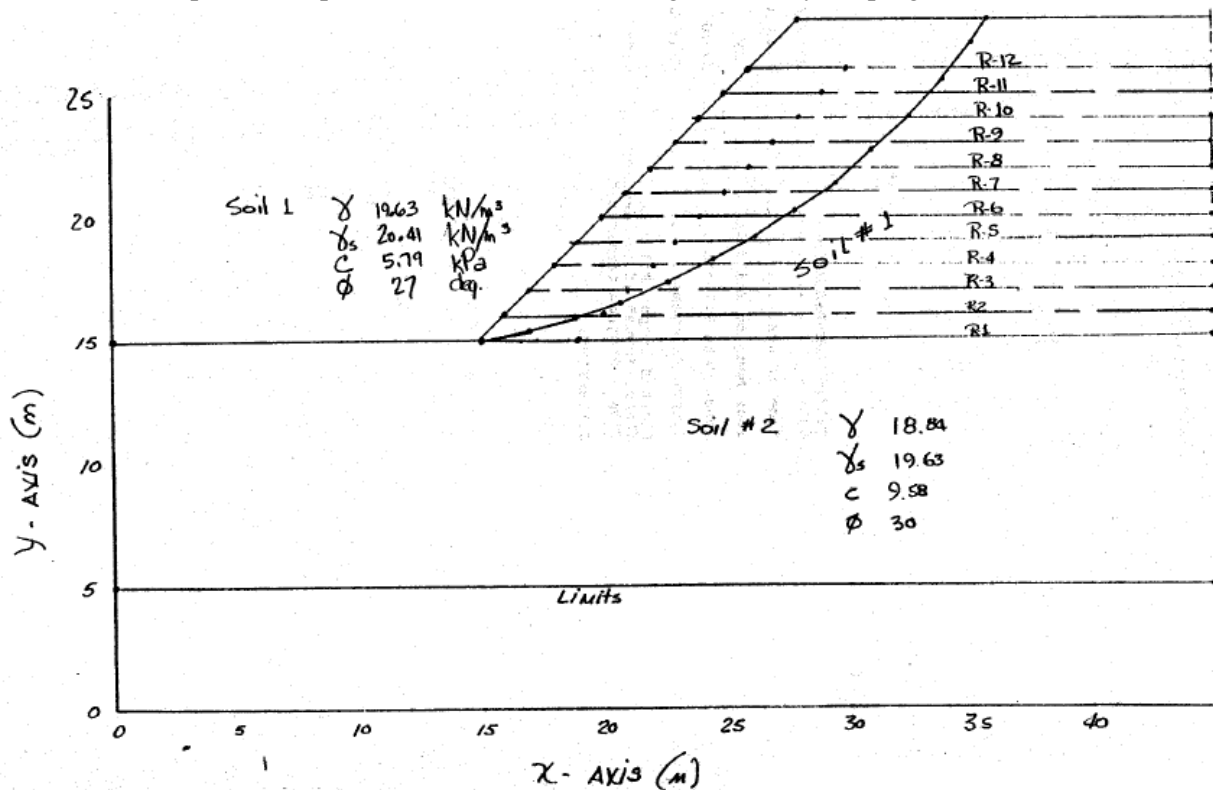


Figure 5.8 General soil description of Example Problem 3.

### 5.5.1 Input Data for Computer Analysis

The contents of the input-data file prepared for Example Problem 4 is reproduced below in courier typeface, for distinction.

```

PROFIL
Example 4 Embankment with reinforcing layers
4 3 1
0. 15. 15. 15. 2
15. 15. 28. 28. 1
28. 28. 45. 28. 1
15. 15. 45. 15. 2
SOIL
2
19.63 20.41 5.79 27. 0. 0. 1
18.84 19.63 9.58 30. 0. 0. 1
LIMITS
1 1
0. 5. 45. 5.
REINF
12
3
15. 15. 0. 0.
19. 15. 7.295 0.
45. 15. 7.295 0.
3
16. 16. 0. 0.
20. 16. 7.295 0.
45. 16. 7.295 0.
3
17. 17. 0. 0.
21. 17. 7.295 0.
45. 17. 7.295 0.
3
18. 18. 0. 0.
22. 18. 7.295 0.
45. 18. 7.295 0.
3
19. 19. 0. 0.
23. 19. 7.295 0.
45. 19. 7.295 0.
3
20. 20. 0. 0.
24. 20. 7.295 0.
45. 20. 7.295 0.
3
21. 21. 0. 0.
25. 21. 7.295 0.
45. 21. 7.295 0.
3
22. 22. 0. 0.
26. 22. 7.295 0.
45. 22. 7.295 0.
3
23. 23. 0. 0.
27. 23. 7.295 0.
45. 23. 7.295 0.
3
24. 24. 0. 0.
28. 24. 7.295 0.
45. 24. 7.295 0.
3

```



```

25. 25. 0. 0.
29. 25. 7.295 0.
45. 25. 7.295 0.
3
26. 26. 0. 0.
30. 26. 7.295 0.
45. 26. 7.295 0.
SURBIS
14
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.
EXECUT

```

### 5.5.2 Output Data

Contents of the output-data file for Example Problem 4 is reproduced below in courier typeface, for distinction.

```

** STABLPro V4.0**

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FHWA-PCSTABLE

1

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

Run Date:
Time of Run:
Run By:
Input Data Filename:
Output Filename:
PROBLEM DESCRIPTION   Example 4 Embankment with reinforcing la
                        yers

BOUNDARY COORDINATES

3 Top   Boundaries
4 Total Boundaries

Boundary   X-Left   Y-Left   X-Right   Y-Right   Soil Type
No.        ft.      ft.      ft.      ft.      Below Bnd

1          0.00   15.00   15.00   15.00   2

```

2	15.00	15.00	28.00	28.00	1
3	28.00	28.00	45.00	28.00	1
4	15.00	15.00	45.00	15.00	2

1

## ISOTROPIC SOIL PARAMETERS

2 Type(s) of Soil

Soil Type No.	Total Unit Wt. pcf	Saturated Unit Wt. pcf	Cohesion Intercept psf	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant psf	Piez. Surface No.
1	19.6	20.4	5.8	27.0	0.00	0.0	1
2	18.8	19.6	9.6	30.0	0.00	0.0	1

1

Searching Routine Will Be Limited To An Area Defined By 1 Boundaries  
Of Which The First 1 Boundaries Will Deflect Surfaces Upward

Boundary No.	X-Left ft.	Y-Left ft.	X-Right ft.	Y-Right ft.
1	0.00	5.00	45.00	5.00

1

## REINFORCING LAYER(S)

12 REINFORCING LAYER(S) SPECIFIED

REINFORCING LAYER NO. 1

3 POINTS DEFINE THIS LAYER

POINT NO.	X-COORD	Y-COORD	FORCE	INCLINATION FACTOR
1	15.00	15.00	0.00	0.000
2	19.00	15.00	7.30	0.000
3	45.00	15.00	7.30	0.000

REINFORCING LAYER NO. 2

3 POINTS DEFINE THIS LAYER

POINT NO.	X-COORD	Y-COORD	FORCE	INCLINATION FACTOR
1	16.00	16.00	0.00	0.000
2	20.00	16.00	7.30	0.000
3	45.00	16.00	7.30	0.000

REINFORCING LAYER NO. 3

3 POINTS DEFINE THIS LAYER

POINT NO.	X-COORD	Y-COORD	FORCE	INCLINATION FACTOR
1	17.00	17.00	0.00	0.000
2	21.00	17.00	7.30	0.000
3	45.00	17.00	7.30	0.000

REINFORCING LAYER NO. 4

3 POINTS DEFINE THIS LAYER

POINT NO.	X-COORD	Y-COORD	FORCE	INCLINATION FACTOR
1	18.00	18.00	0.00	0.000
2	22.00	18.00	7.30	0.000
3	45.00	18.00	7.30	0.000

REINFORCING LAYER NO. 5

3 POINTS DEFINE THIS LAYER

POINT NO.	X-COORD	Y-COORD	FORCE	INCLINATION FACTOR
1	19.00	19.00	0.00	0.000
2	23.00	19.00	7.30	0.000
3	45.00	19.00	7.30	0.000

REINFORCING LAYER NO. 6

3 POINTS DEFINE THIS LAYER

POINT NO.	X-COORD	Y-COORD	FORCE	INCLINATION FACTOR
1	20.00	20.00	0.00	0.000
2	24.00	20.00	7.30	0.000
3	45.00	20.00	7.30	0.000

REINFORCING LAYER NO. 7

3 POINTS DEFINE THIS LAYER

POINT NO.	X-COORD	Y-COORD	FORCE	INCLINATION FACTOR
1	21.00	21.00	0.00	0.000
2	25.00	21.00	7.30	0.000
3	45.00	21.00	7.30	0.000

REINFORCING LAYER NO. 8

3 POINTS DEFINE THIS LAYER

POINT NO.	X-COORD	Y-COORD	FORCE	INCLINATION FACTOR
1	22.00	22.00	0.00	0.000
2	26.00	22.00	7.30	0.000
3	45.00	22.00	7.30	0.000

REINFORCING LAYER NO. 9

3 POINTS DEFINE THIS LAYER

POINT NO.	X-COORD	Y-COORD	FORCE	INCLINATION FACTOR
1	23.00	23.00	0.00	0.000
2	27.00	23.00	7.30	0.000
3	45.00	23.00	7.30	0.000

REINFORCING LAYER NO. 10

3 POINTS DEFINE THIS LAYER

POINT NO.	X-COORD	Y-COORD	FORCE	INCLINATION FACTOR
1	24.00	24.00	0.00	0.000
2	28.00	24.00	7.30	0.000
3	45.00	24.00	7.30	0.000

REINFORCING LAYER NO. 11

3 POINTS DEFINE THIS LAYER

POINT NO.	X-COORD	Y-COORD	FORCE	INCLINATION FACTOR
1	25.00	25.00	0.00	0.000
2	29.00	25.00	7.30	0.000
3	45.00	25.00	7.30	0.000

REINFORCING LAYER NO. 12

3 POINTS DEFINE THIS LAYER

POINT NO.	X-COORD	Y-COORD	FORCE	INCLINATION FACTOR
1	26.00	26.00	0.00	0.000

	2	30.00	26.00	7.30	0.000
1	3	45.00	26.00	7.30	0.000

Trial Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	15.00	15.00
2	17.00	15.40
3	18.90	15.90
4	20.80	16.50
5	22.70	17.30
6	24.50	18.20
7	26.20	19.10
8	27.90	20.20
9	29.50	21.40
10	31.00	22.70
11	32.50	24.00
12	33.90	25.50
13	35.10	27.00
14	35.80	28.00

Circle Center At X = 9.5 ; Y = 47.9 and Radius, 33.4

Factor Of Safety For The Preceding Specified Surface = 1.125

### 5.5.3 Graphical Results of Computer Analysis

The factor of safety for the same specified failure surface without tiebacks is 1.113. The factor of safety for the specified failure surface increases to 1.629 with the tieback as shown in Figure 5.7.

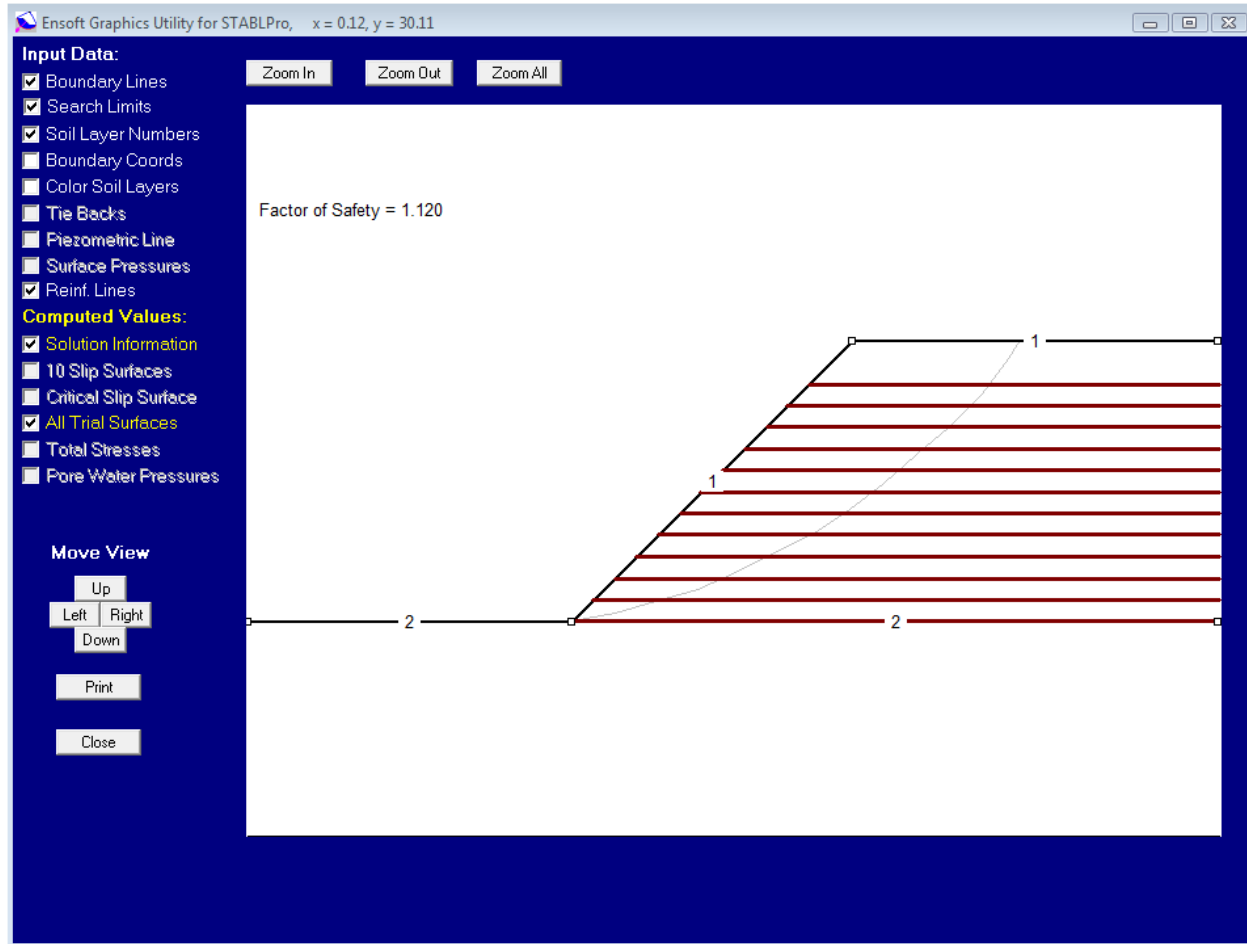


Figure 5.9 Plot of the block-failure surface with tiebacks of Example Problem 3.

## 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 dense sand deposit. The coordinates of each line for defining the soil profile and surface are shown in Fig. 5.10 and the slope profile is shown in Fig. 5.11.

The factor of safety against the slope failure based on the Simplified Bishop Method is 1.041 as shown in Fig. 5.12. Two tiebacks are considered to increase the stability of the slope. The location and parameters of each tieback are shown in Fig. 5.13. The Simplified Bishop method was used for analyzing the slope with the support of tiebacks. The factor of safety against failure increases from 1.041 to 1.230 as shown in Fig. 5.14. All the trial surfaces, which cover extensive area, are also plotted in the same figure for reference.

	Left X (m)	Left Y (m)	Right X (m)	Right Y (m)	Soil Number
1	54.9	68.4	67.7	67.1	1
2	67.7	67.1	72	69.2	1
3	72	69.2	80	70.7	1
4	80	70.7	85	75.3	1
5	85	75.3	90.5	78.2	1
6	90.5	78.2	110	78.2	1
7	54.8	64.9	90.5	68.9	2
8	90.5	68.9	110	68.9	2
9	54.9	63.1	90.5	60	3
10	90.5	60	101	64	3
11	101	64	110	63	3
12	54.9	57.3	90.5	57.3	4
13	90.5	57.3	101	62.5	4
14	101	62.5	110	61.5	4

Figure 5.10 Coordinates of each line of the soil profile and the ground surface of Example Problem 5.

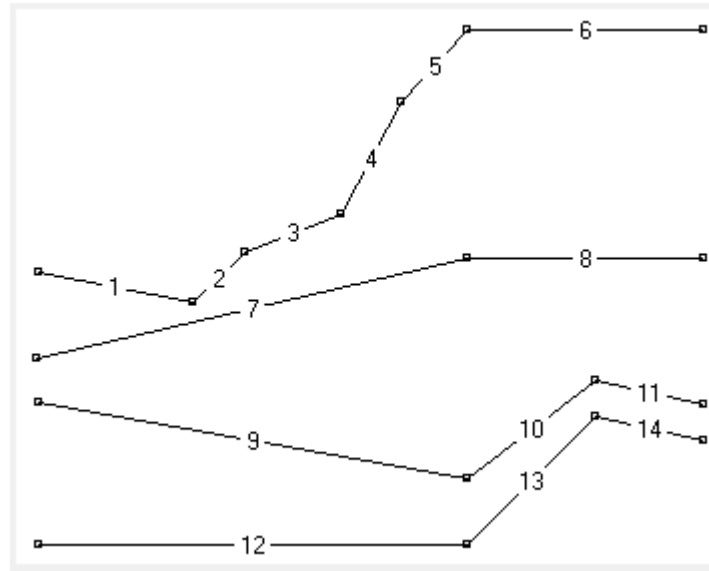


Figure 5.11 General soil profile of Example Problem 5.

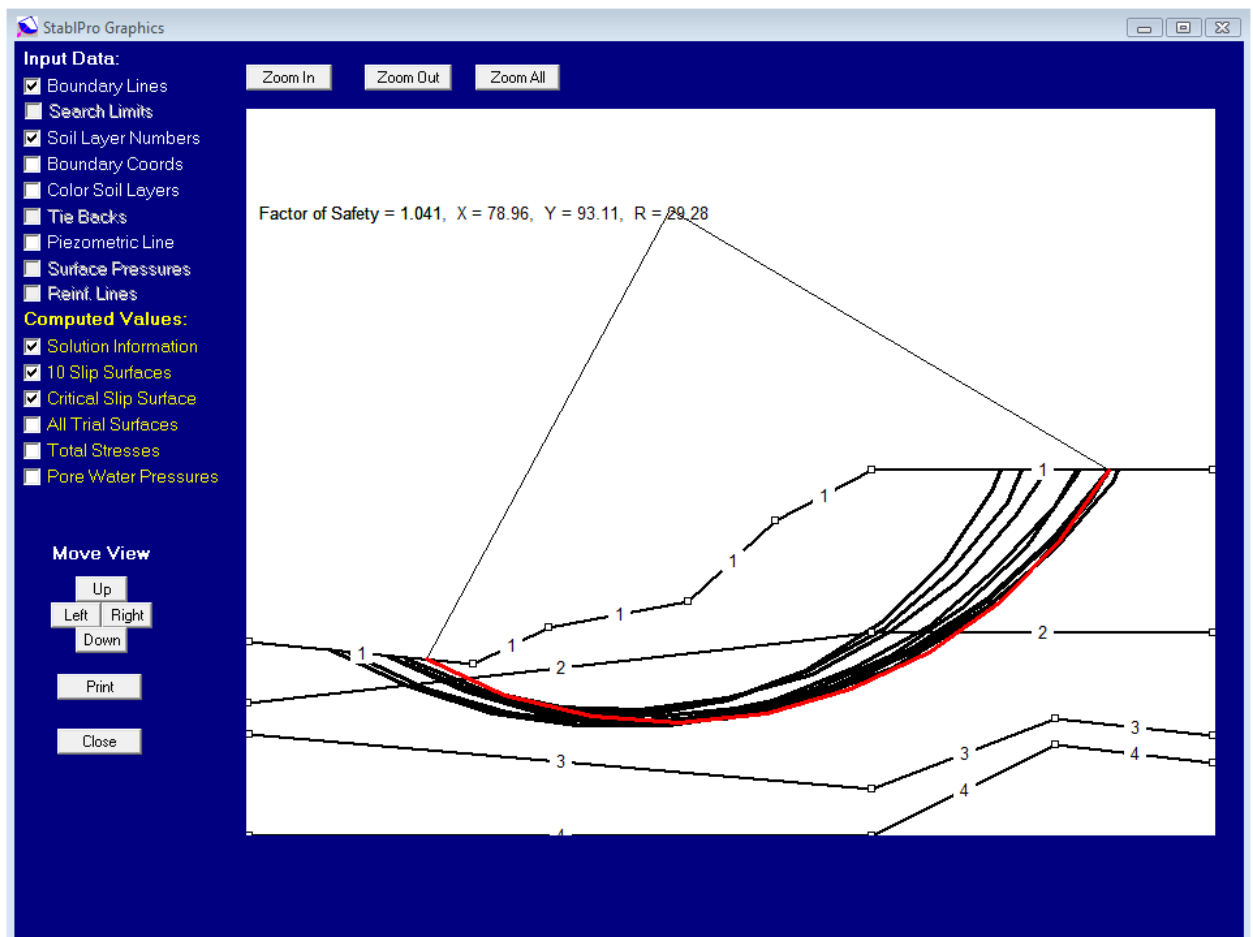


Figure 5.12 The most critical slope (F.S. = 1.041) of Example Problem 5.



User-Specified Tieback Data							
Point	Boundary	X Coord.	Y Coord.	Load (kN)	Spacing	Inclination	Free Length (m)
	Surface #	(m)	(m)		(m)	(DEG.)	
1	2	0	68	337	2.8	0	60
2	3	0	70	296.4	2.8	0	60

15 tiebacks maximum

Figure 5.13 The coordinates and parameters of tiebacks used in Example Problem 5.

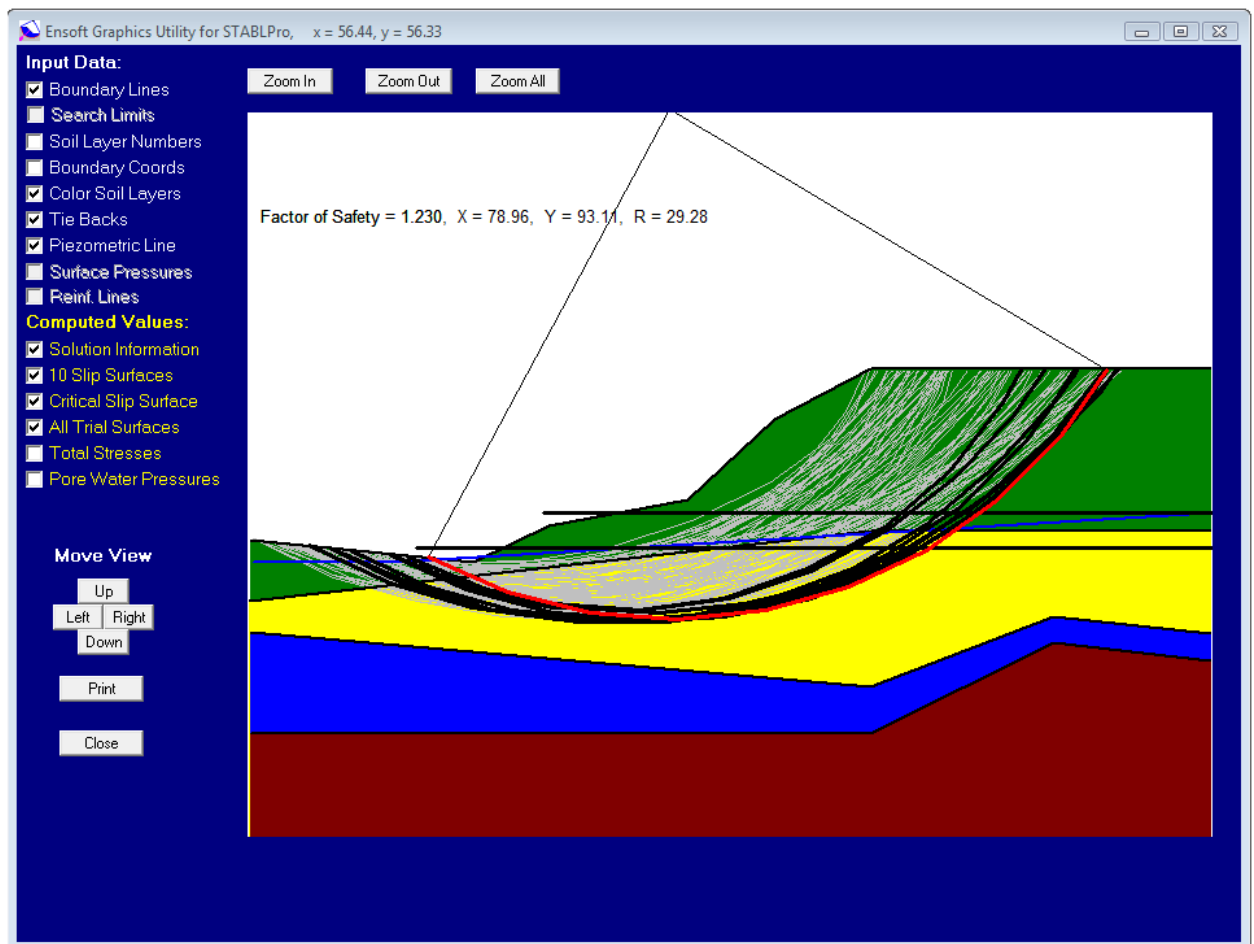


Figure 5.14 The most critical slope (F.S. = 1.230) of Example Problem 5 with support from two tiebacks.

### 5.6.1 Input Data for Computer Analysis

The contents of the input-data file prepared for Example Problem 5 is reproduced below in courier typeface, for distinction.

```
PROFIL
Example #5
14 6 2
54.9 68.4 67.7 67.1 1
67.7 67.1 72. 69.2 1
72. 69.2 80. 70.7 1
80. 70.7 85. 75.3 1
85. 75.3 90.5 78.2 1
90.5 78.2 110. 78.2 1
54.8 64.9 90.5 68.9 2
90.5 68.9 110. 68.9 2
54.9 63.1 90.5 60. 3
90.5 60. 101. 64. 3
101. 64. 110. 63. 3
54.9 57.3 90.5 57.3 4
90.5 57.3 101. 62.5 4
101. 62.5 110. 61.5 4
SOIL
4
19.6 19.6 47.9 0. 0. 0. 1
17.3 17.3 23.9 0. 0. 0. 1
17.3 17.3 36.3 0. 0. 0. 1
19.6 19.6 0. 35. 0. 0. 1
WATER
1 9.8
3
55. 67.1
63. 67.1
110. 70.
TIES
2
2 0. 68. 337. 2.8 0. 60.
3 0. 70. 296.4 2.8 0. 60.
CIRCL2
10 10
55. 65. 90. 105.
50. 5. 0. -25.
EXECUT
```

### 5.6.2 Output Data

Contents of the output-data file for Example Problem 5 is reproduced below in courier typeface, for distinction.

```

** STABLPro V4.0**

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FHWA-PCSTABLE

1

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

Run Date:
```

Run Date:  
 Time of Run:  
 Run By:  
 Input Data Filename:  
 Output Filename:  
 Plotted Output Filename:

# PROBLEM DESCRIPTION Example #5

## BOUNDARY COORDINATES

6 Top Boundaries  
 14 Total Boundaries

Boundary No.	X-Left M	Y-Left M	X-Right M	Y-Right M	Soil Type Below Bnd
1	54.90	68.40	67.70	67.10	1
2	67.70	67.10	72.00	69.20	1
3	72.00	69.20	80.00	70.70	1
4	80.00	70.70	85.00	75.30	1
5	85.00	75.30	90.50	78.20	1
6	90.50	78.20	110.00	78.20	1
7	54.80	64.90	90.50	68.90	2
8	90.50	68.90	110.00	68.90	2
9	54.90	63.10	90.50	60.00	3
10	90.50	60.00	101.00	64.00	3
11	101.00	64.00	110.00	63.00	3
12	54.90	57.30	90.50	57.30	4
13	90.50	57.30	101.00	62.50	4
14	101.00	62.50	110.00	61.50	4

1

## ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. kN/M <sup>3</sup>	Saturated Unit Wt. kN/M <sup>3</sup>	Cohesion Intercept kPa	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant kPa	Piez. Surface No.
1	19.6	19.6	47.9	0.0	0.00	0.0	1
2	17.3	17.3	23.9	0.0	0.00	0.0	1
3	17.3	17.3	36.3	0.0	0.00	0.0	1
4	19.6	19.6	0.0	35.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 9.80 kN/M<sup>3</sup>

Piezometric Surface No. 1 Specified by 3 Coordinate Points

Point No.	X-Water M	Y-Water M
1	55.00	67.10
2	63.00	67.10
3	110.00	70.00

1

TIEBACK LOAD(S)

2 Tieback Load(s) Specified

Tieback No.	X-Pos M	Y-Pos M	Load KN	Spacing M	Inclination (deg)	Length M
1	69.54	68.00	337.0	2.8	0.00	60.0
2	76.27	70.00	296.4	2.8	0.00	60.0

NOTE - An Equivalent Line Load Is Calculated For Each Row Of Tiebacks  
Assuming A Uniform Distribution Of Load Horizontally Between  
Individual Tiebacks.

1

A Critical Failure Surface Searching Method, Using A Random  
Technique For Generating Circular Surfaces, Has Been Specified.

100 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 10 Points Equally Spaced  
Along The Ground Surface Between X = 55.00 M  
and X = 65.00 M

Each Surface Terminates Between X = 90.00 M  
and X = 105.00 M

Unless Further Limitations Were Imposed, The Minimum Elevation  
At Which A Surface Extends Is Y = 50.00 M

5.00 M Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation.  
The Angle Has Been Restricted Between The Angles Of -25.0  
And 0.0 deg.

1

Following Are Displayed The Ten Most Critical Of The Trial  
Failure Surfaces Examined. They Are Ordered - Most Critical  
First.

\* \* Safety Factors Are Calculated By The Modified Bishop Method \* \*

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf M	Y-Surf M
1	65.00	67.37
2	69.58	65.37
3	74.44	64.18
4	79.43	63.83
5	84.40	64.34
6	89.22	65.68
7	93.73	67.83
8	97.82	70.71
9	101.36	74.24
10	104.15	78.20

Circle Center At X = 79.0 ; Y = 93.1 and Radius, 29.3

\*\*\* 1.230 \*\*\*

Individual data on the 20 slices

Slice No.	Width Ft (m)	Weight Lbs (kg)	Water		Tie		Earthquake		Surcharge Load
			Force Top	Force Bot	Force Norm	Force Tan	Force Hor	Force Ver	
			Lbs (kg)	Lbs (kg)	Lbs (kg)	Lbs (kg)	Lbs (kg)	Lbs (kg)	Lbs (kg)
1	0.3	0.30E+00	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
2	2.1	0.19E+02	0.15E+01	0.12E+02	0.00E+00	0.0	0.0	0.0	0.0
3	0.3	0.46E+01	0.72E+00	0.33E+01	0.00E+00	0.0	0.0	0.0	0.0
4	1.9	0.63E+02	0.00E+00	0.33E+02	0.00E+00	0.0	0.0	0.0	0.0
5	2.4	0.16E+03	0.00E+00	0.61E+02	0.10E+02	10.2	0.0	0.0	0.0
6	2.4	0.22E+03	0.00E+00	0.80E+02	0.17E+02	17.1	0.0	0.0	0.0
7	5.0	0.56E+03	0.00E+00	0.19E+03	0.28E+02	27.6	0.0	0.0	0.0
8	0.6	0.71E+02	0.00E+00	0.24E+02	0.36E+01	3.6	0.0	0.0	0.0
9	4.4	0.70E+03	0.00E+00	0.18E+03	0.34E+02	34.1	0.0	0.0	0.0
10	0.6	0.12E+03	0.00E+00	0.24E+02	0.44E+01	4.4	0.0	0.0	0.0
11	3.5	0.73E+03	0.00E+00	0.13E+03	0.26E+02	25.7	0.0	0.0	0.0
12	0.8	0.17E+03	0.00E+00	0.24E+02	0.55E+01	5.5	0.0	0.0	0.0
13	1.3	0.29E+03	0.00E+00	0.39E+02	0.86E+01	8.6	0.0	0.0	0.0
14	1.7	0.37E+03	0.00E+00	0.39E+02	0.11E+02	11.0	0.0	0.0	0.0
15	1.6	0.32E+03	0.00E+00	0.25E+02	0.99E+01	9.9	0.0	0.0	0.0
16	1.5	0.29E+03	0.00E+00	0.12E+02	0.92E+01	9.2	0.0	0.0	0.0
17	0.3	0.53E+02	0.00E+00	0.34E+00	0.18E+01	1.8	0.0	0.0	0.0
18	2.3	0.37E+03	0.00E+00	0.00E+00	0.13E+02	13.1	0.0	0.0	0.0
19	3.5	0.40E+03	0.00E+00	0.00E+00	0.20E+02	19.6	0.0	0.0	0.0
20	2.8	0.11E+03	0.00E+00	0.00E+00	0.12E+02	12.1	0.0	0.0	0.0

-----  
Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf M	Y-Surf M
1	62.78	67.60
2	67.34	65.56
3	72.17	64.27
4	77.15	63.76
5	82.14	64.06
6	87.02	65.14
7	91.67	66.99
8	95.96	69.55
9	99.79	72.76
10	103.06	76.55
11	104.08	78.20

Circle Center At X = 77.8 ; Y = 95.1 and Radius, 31.3

\*\*\* 1.277 \*\*\*

1

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf M	Y-Surf M
1	62.78	67.60
2	67.33	65.53
3	72.16	64.25
4	77.14	63.82
5	82.13	64.25
6	86.96	65.51
7	91.52	67.58
8	95.65	70.39
9	99.25	73.86
10	102.20	77.90
11	102.35	78.20

Circle Center At X = 77.2 ; Y = 93.1 and Radius, 29.3

\*\*\* 1.304 \*\*\*

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf M	Y-Surf M
1	63.89	67.49
2	68.53	65.62
3	73.40	64.51
4	78.39	64.19

5	83.37	64.67
6	88.21	65.92
7	92.79	67.93
8	96.99	70.65
9	100.71	73.99
10	103.85	77.88
11	104.03	78.20

Circle Center At X = 77.9 ; Y = 95.6 and Radius, 31.4

\*\*\* 1.320 \*\*\*

1

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf M	Y-Surf M
1	59.44	67.94
2	63.99	65.85
3	68.78	64.43
4	73.73	63.71
5	78.73	63.70
6	83.68	64.40
7	88.48	65.81
8	93.03	67.88
9	97.24	70.57
10	101.02	73.85
11	104.30	77.62
12	104.67	78.20

Circle Center At X = 76.3 ; Y = 98.6 and Radius, 35.0

\*\*\* 1.355 \*\*\*

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf M	Y-Surf M
1	59.44	67.94
2	63.98	65.83
3	68.77	64.40
4	73.72	63.69
5	78.72	63.72
6	83.66	64.48
7	88.44	65.96
8	92.95	68.12
9	97.09	70.92
10	100.77	74.30
11	103.92	78.19
12	103.93	78.20

Circle Center At X = 76.0 ; Y = 97.6 and Radius, 34.0

\*\*\* 1.360 \*\*\*

1

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf M	Y-Surf M
1	60.56	67.83
2	65.09	65.72
3	69.90	64.37
4	74.87	63.80
5	79.87	64.03
6	84.76	65.05
7	89.43	66.84
8	93.75	69.35
9	97.62	72.52
10	100.93	76.27
11	102.15	78.20

Circle Center At X = 75.9 ; Y = 95.0 and Radius, 31.3

\*\*\* 1.372 \*\*\*

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf M	Y-Surf M
1	58.33	68.05
2	62.89	65.99
3	67.68	64.57
4	72.63	63.82
5	77.62	63.75
6	82.59	64.38
7	87.41	65.68
8	92.02	67.63
9	96.31	70.19
10	100.21	73.32
11	103.65	76.95
12	104.54	78.20

Circle Center At X = 75.6 ; Y = 100.0 and Radius, 36.3

\*\*\* 1.413 \*\*\*

1

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf M	Y-Surf M
--------------	-------------	-------------



1	62.78	67.60
2	67.41	65.72
3	72.30	64.66
4	77.29	64.46
5	82.25	65.12
6	87.02	66.63
7	91.45	68.93
8	95.43	71.97
9	98.82	75.64
10	100.47	78.20

Circle Center At X = 75.9 ; Y = 93.4 and Radius, 28.9

\*\*\* 1.430 \*\*\*

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf M	Y-Surf M
1	62.78	67.60
2	67.36	65.61
3	72.24	64.50
4	77.24	64.32
5	82.18	65.06
6	86.90	66.71
7	91.23	69.20
8	95.03	72.46
9	98.16	76.36
10	99.13	78.20

Circle Center At X = 75.7 ; Y = 91.1 and Radius, 26.9

\*\*\* 1.440 \*\*\*

## 5.7 Example Problem 6 (Complicated Slope Geometry)

The six example problem demonstrates an application with complicated soil conditions (8 soil layers) and geometry (24 sectional lines on a bluff) which can be handled by STABLPRO. The layer of each sectional line for defining the soil profile and surface are shown in Fig. 5.15 and the soil-layer numbers is shown in Fig. 5.16. A area with graben debris was defined by Lines 16, 17, 19 and 20.

The factor of safety against the slope failure based on the Simplified Bishop Method is 1.305 as shown in Fig. 5.17.

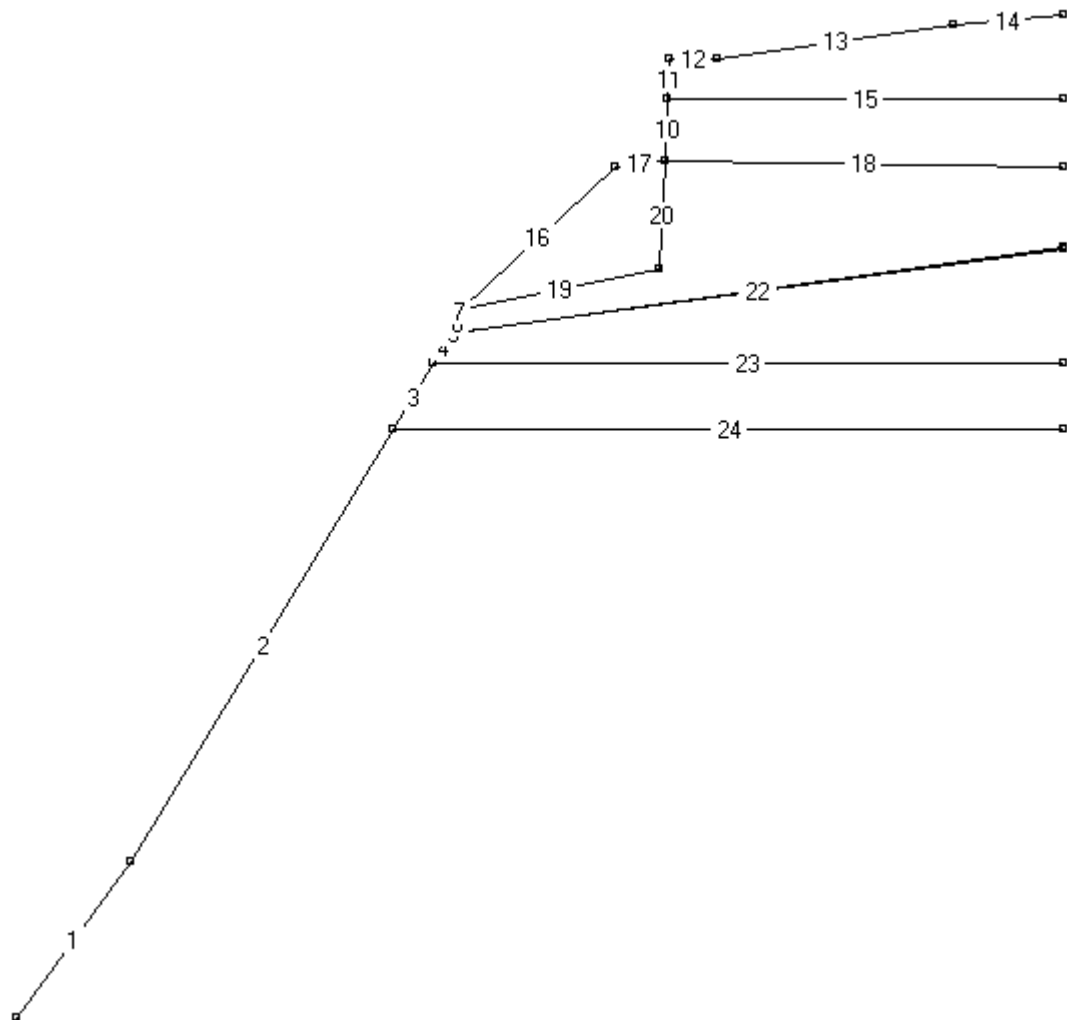


Figure 5.15 Layout of sectional lines of Example Problem 6.

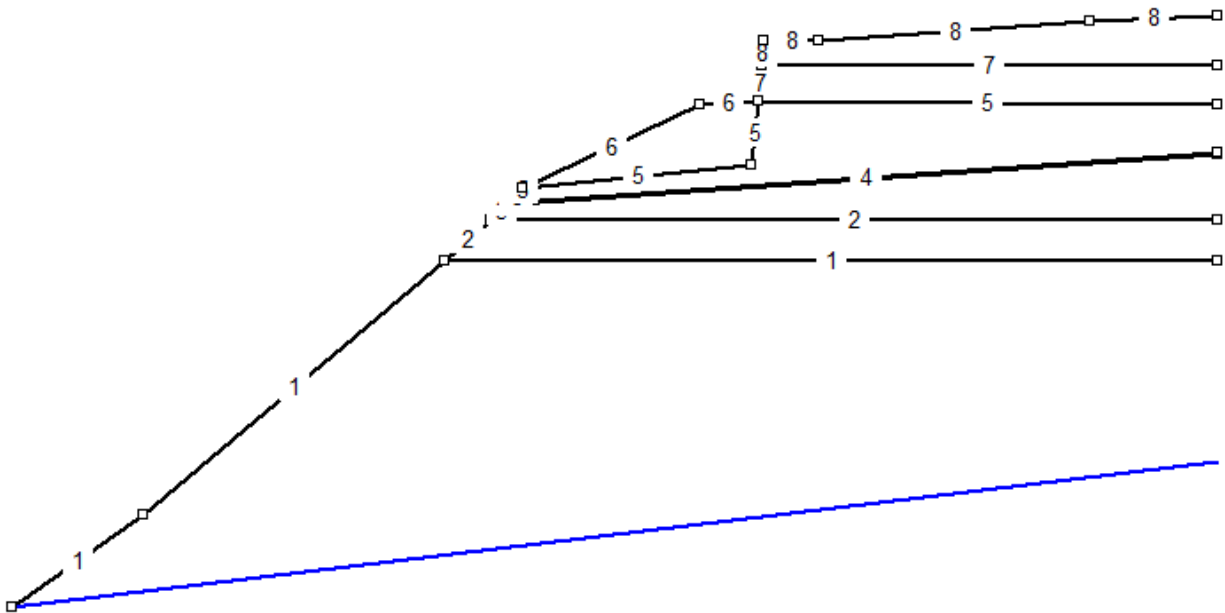


Figure 5.16 Layout of soil layer numbers of Example Problem 6.

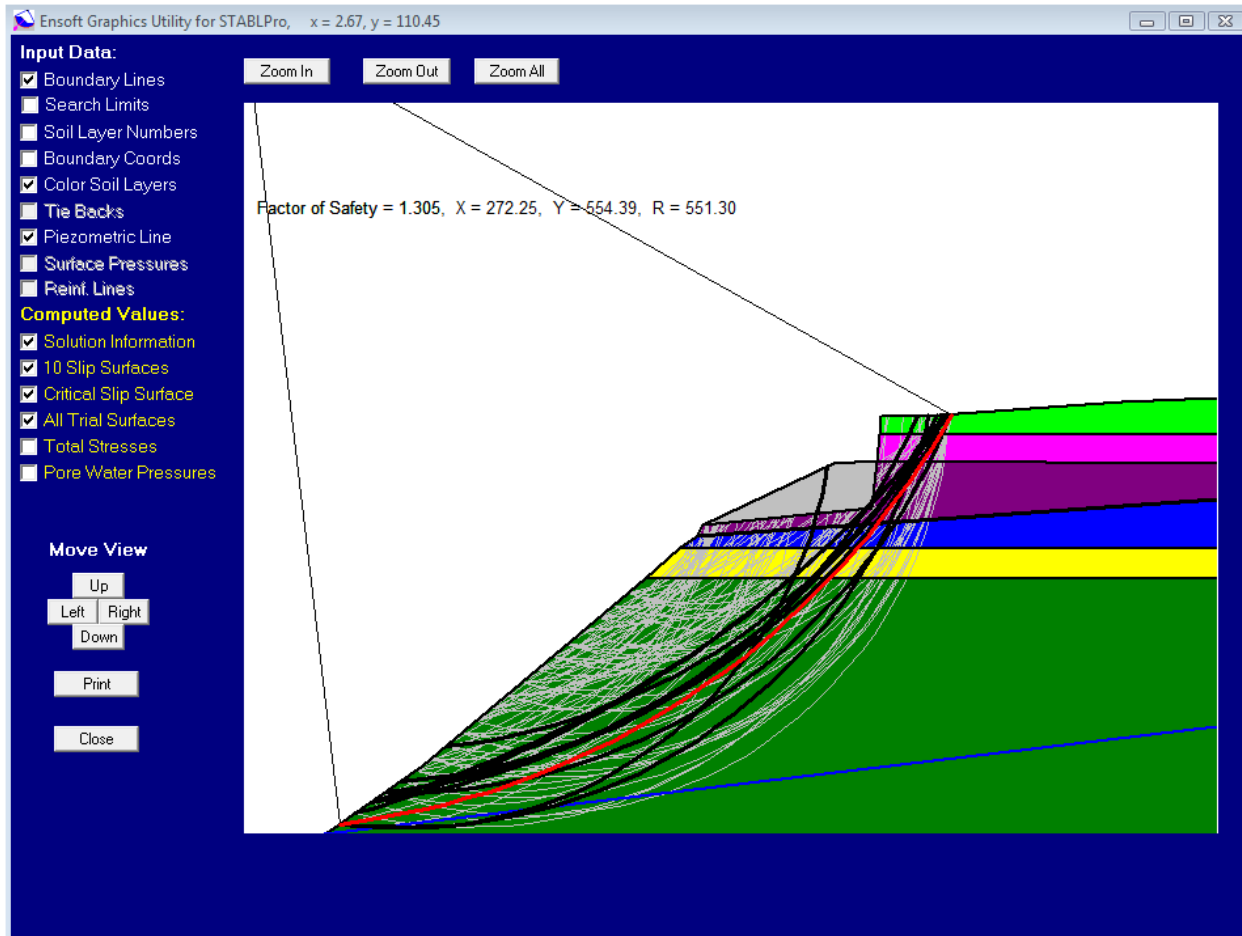


Figure 5.17 The most critical slope (F.S. = 1.041) of Example Problem 6.

### 5.7.1 Input Data for Computer Analysis

The contents of the input-data file prepared for Example Problem 6 is reproduced below in courier typeface, for distinction.

```
PROFIL
Example 6
24 14 2
54. 0. 120. 46. 1
120. 46. 272. 174. 1
272. 174. 295. 194. 2
295. 194. 306. 202.6 3
306. 202.6 307. 203. 4
307. 203. 310. 208.5 5
310. 208.5 311. 210. 5
311. 210. 400. 252. 6
400. 252. 429. 254. 6
429. 254. 431. 272. 7
431. 272. 432. 284. 8
432. 284. 460. 284. 8
```

```

460. 284. 596. 294. 8
596. 294. 660. 297. 8
431. 272. 660. 272. 7
311. 210. 400. 252. 6
400. 252. 429. 254. 6
429. 254. 660. 252. 5
311. 210. 426. 222. 5
426. 222. 429. 254. 5
307. 203. 660. 228. 4
306. 202.6 660. 227.5 3
295. 194. 660. 194. 2
272. 174. 660. 174. 1
SOIL
8
21.206809 21. 380. 25. 0. 0. 1
20.421372 20.5 72. 28. 0. 0. 1
19.635935 19.6 55. 30. 0. 0. 1
17.279623 18.2 0. 20. 0. 0. 1
18.850497 19.6 48. 25. 0. 0. 1
18.850497 21. 10. 25. 0. 0. 1
18.850497 18.9 47.880263 0. 0. 0. 1
18.850497 18.9 71.820395 0. 0. 0. 1
WATER
1 9.8
2
54. 0.
660. 73.152
LIMITS
1 1
0. 0. 0. 0.
CIRCL2
20 5
64. 260. 300. 480.
0. 15. 0. 0.
EXECUT

```

## 5.7.2 Output Data

Contents of the output-data file for Example Problem 6 is reproduced below in courier typeface, for distinction.

```

** STABLPro V4.0**

Upgraded from
FHWA-PCSTABLE

1

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

Run Date:
Time of Run:
Run By:
Input Data Filename:
Output Filename:
Plotted Output Filename:

```

PROBLEM DESCRIPTION Example 6

BOUNDARY COORDINATES

14 Top Boundaries  
24 Total Boundaries

Boundary No.	X-Left M	Y-Left M	X-Right M	Y-Right M	Soil Type Below Bnd
1	54.00	0.00	120.00	46.00	1
2	120.00	46.00	272.00	174.00	1
3	272.00	174.00	295.00	194.00	2
4	295.00	194.00	306.00	202.60	3
5	306.00	202.60	307.00	203.00	4
6	307.00	203.00	310.00	208.50	5
7	310.00	208.50	311.00	210.00	5
8	311.00	210.00	400.00	252.00	6
9	400.00	252.00	429.00	254.00	6
10	429.00	254.00	431.00	272.00	7
11	431.00	272.00	432.00	284.00	8
12	432.00	284.00	460.00	284.00	8
13	460.00	284.00	596.00	294.00	8
14	596.00	294.00	660.00	297.00	8
15	431.00	272.00	660.00	272.00	7
16	311.00	210.00	400.00	252.00	6
17	400.00	252.00	429.00	254.00	6
18	429.00	254.00	660.00	252.00	5
19	311.00	210.00	426.00	222.00	5
20	426.00	222.00	429.00	254.00	5
21	307.00	203.00	660.00	228.00	4
22	306.00	202.60	660.00	227.50	3
23	295.00	194.00	660.00	194.00	2
24	272.00	174.00	660.00	174.00	1

1

ISOTROPIC SOIL PARAMETERS

8 Type(s) of Soil

Soil Type No.	Total Unit Wt. kN/M <sup>3</sup>	Saturated Unit Wt. kN/M <sup>3</sup>	Cohesion Intercept kPa	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant kPa	Piez. Surface No.
1	21.2	21.0	380.0	25.0	0.00	0.0	1
2	20.4	20.5	72.0	28.0	0.00	0.0	1
3	19.6	19.6	55.0	30.0	0.00	0.0	1
4	17.3	18.2	0.0	20.0	0.00	0.0	1
5	18.9	19.6	48.0	25.0	0.00	0.0	1
6	18.9	21.0	10.0	25.0	0.00	0.0	1
7	18.9	18.9	47.9	0.0	0.00	0.0	1
8	18.9	18.9	71.8	0.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 9.80 kN/M<sup>3</sup>

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water M	Y-Water M
1	54.00	0.00
2	660.00	73.15

1

Searching Routine Will Be Limited To An Area Defined By 1 Boundaries  
Of Which The First 1 Boundaries Will Deflect Surfaces Upward

Boundary No.	X-Left M	Y-Left M	X-Right M	Y-Right M
1	0.00	0.00	0.00	0.00

1

A Critical Failure Surface Searching Method, Using A Random  
Technique For Generating Circular Surfaces, Has Been Specified.

100 Trial Surfaces Have Been Generated.

5 Surfaces Initiate From Each Of 20 Points Equally Spaced  
Along The Ground Surface Between X = 64.00 M  
and X = 260.00 M

Each Surface Terminates Between X = 300.00 M  
and X = 480.00 M

Unless Further Limitations Were Imposed, The Minimum Elevation  
At Which A Surface Extends Is Y = 0.00 M

15.00 M Line Segments Define Each Trial Failure Surface.

1

Following Are Displayed The Ten Most Critical Of The Trial  
Failure Surfaces Examined. They Are Ordered - Most Critical  
First.

\* \* Safety Factors Are Calculated By The Modified Bishop Method \* \*

Failure Surface Specified By 36 Coordinate Points

Point No.	X-Surf M	Y-Surf M
1	64.00	6.97
2	78.87	8.95
3	93.68	11.33
4	108.42	14.11
5	123.08	17.30
6	137.64	20.88
7	152.11	24.86
8	166.46	29.23
9	180.68	33.98
10	194.77	39.13
11	208.72	44.65
12	222.51	50.55
13	236.13	56.83
14	249.58	63.47
15	262.85	70.47
16	275.91	77.84
17	288.78	85.56
18	301.42	93.62
19	313.85	102.03
20	326.04	110.77
21	337.99	119.84
22	349.68	129.23
23	361.12	138.93
24	372.29	148.94
25	383.18	159.26
26	393.79	169.86
27	404.10	180.75
28	414.12	191.92
29	423.83	203.35
30	433.22	215.05
31	442.29	227.00
32	451.03	239.18
33	459.44	251.61
34	467.51	264.25
35	475.23	277.11
36	479.94	285.47

Circle Center At X = -1.3 ; Y = 554.4 and Radius, 551.3

\*\*\* 1.305 \*\*\*

Individual data on the 54 slices

Slice No.	Width Ft (m)	Weight Lbs (kg)	Water	Water	Tie	Tie	Earthquake		Surcharge Load
			Force Top	Force Bot	Force Norm	Force Tan	Force Hor	Force Ver	
1	14.9	0.13E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
2	14.8	0.39E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
3	14.7	0.63E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
4	11.6	0.65E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
5	3.1	0.20E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
6	14.6	0.11E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0



7	14.5	0.14E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
8	14.3	0.16E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
9	14.2	0.18E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
10	14.1	0.20E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
11	13.9	0.22E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
12	13.8	0.23E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
13	13.6	0.24E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
14	13.4	0.25E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
15	13.3	0.26E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
16	9.2	0.19E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
17	3.9	0.82E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
18	12.9	0.28E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
19	6.2	0.14E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
20	6.4	0.14E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
21	4.6	0.10E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
22	1.0	0.22E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
23	3.0	0.67E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
24	1.0	0.23E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
25	2.8	0.65E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
26	12.2	0.27E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
27	11.9	0.26E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
28	11.7	0.24E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
29	11.4	0.22E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
30	11.2	0.21E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
31	10.9	0.19E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
32	10.6	0.17E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
33	3.9	0.60E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
34	2.3	0.34E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
35	4.1	0.58E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
36	10.0	0.13E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
37	1.8	0.20E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
38	7.9	0.83E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
39	2.2	0.20E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
40	3.0	0.26E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
41	1.2	0.11E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
42	0.3	0.34E+03	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
43	0.4	0.47E+03	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
44	1.0	0.12E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
45	1.2	0.16E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
46	9.1	0.11E+05	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
47	8.7	0.84E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
48	8.4	0.61E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
49	0.6	0.34E+03	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
50	0.8	0.46E+03	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
51	6.7	0.32E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
52	4.7	0.15E+04	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
53	3.1	0.60E+03	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0
54	4.7	0.36E+03	0.00E+00	0.00E+00	0.00E+00	0.0	0.0	0.0	0.0

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf M	Y-Surf M
1	84.63	21.35
2	99.44	23.74
3	114.18	26.53
4	128.83	29.74
5	143.39	33.35
6	157.85	37.36
7	172.18	41.77

8	186.39	46.57
9	200.46	51.77
10	214.38	57.35
11	228.15	63.32
12	241.74	69.67
13	255.15	76.39
14	268.37	83.48
15	281.38	90.93
16	294.19	98.75
17	306.77	106.91
18	319.12	115.42
19	331.24	124.27
20	343.10	133.45
21	354.70	142.95
22	366.04	152.77
23	377.10	162.91
24	387.87	173.34
25	398.35	184.07
26	408.53	195.09
27	418.41	206.39
28	427.96	217.95
29	437.19	229.77
30	446.09	241.85
31	454.65	254.17
32	462.87	266.72
33	470.73	279.49
34	473.93	285.02

Circle Center At X = 5.9 ; Y = 556.9 and Radius, 541.3

\*\*\* 1.330 \*\*\*

1

Failure Surface Specified By 33 Coordinate Points

Point No.	X-Surf M	Y-Surf M
1	94.95	28.54
2	109.83	30.45
3	124.64	32.81
4	139.38	35.61
5	154.02	38.85
6	168.56	42.54
7	182.98	46.66
8	197.28	51.21
9	211.43	56.19
10	225.42	61.59
11	239.24	67.41
12	252.89	73.65
13	266.34	80.29
14	279.58	87.33
15	292.60	94.77
16	305.40	102.60
17	317.95	110.81
18	330.25	119.40
19	342.29	128.35
20	354.05	137.65
21	365.53	147.31

22	376.71	157.31
23	387.59	167.64
24	398.15	178.30
25	408.38	189.26
26	418.28	200.53
27	427.83	212.10
28	437.04	223.94
29	445.88	236.06
30	454.35	248.43
31	462.45	261.06
32	470.17	273.92
33	476.48	285.21

Circle Center At X = 38.9 ; Y = 523.8 and Radius, 498.4

\*\*\* 1.336 \*\*\*

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf M	Y-Surf M
1	94.95	28.54
2	109.95	28.49
3	124.94	28.99
4	139.90	30.06
5	154.81	31.68
6	169.66	33.85
7	184.41	36.58
8	199.04	39.85
9	213.55	43.66
10	227.91	48.02
11	242.09	52.90
12	256.08	58.31
13	269.86	64.24
14	283.41	70.67
15	296.71	77.60
16	309.74	85.03
17	322.49	92.94
18	334.94	101.31
19	347.06	110.14
20	358.85	119.42
21	370.28	129.13
22	381.34	139.26
23	392.02	149.79
24	402.30	160.71
25	412.17	172.01
26	421.61	183.67
27	430.61	195.67
28	439.15	208.00
29	447.23	220.64
30	454.83	233.57
31	461.95	246.77
32	468.57	260.23
33	474.69	273.93
34	479.31	285.42

Circle Center At X = 103.9 ; Y = 431.3 and Radius, 402.8

\*\*\* 1.356 \*\*\*

1

Failure Surface Specified By 37 Coordinate Points

Point No.	X-Surf M	Y-Surf M
1	64.00	6.97
2	78.93	5.52
3	93.91	4.68
4	108.90	4.45
5	123.90	4.83
6	138.87	5.83
7	153.78	7.43
8	168.62	9.64
9	183.35	12.45
10	197.96	15.86
11	212.42	19.86
12	226.70	24.45
13	240.78	29.61
14	254.64	35.35
15	268.25	41.64
16	281.60	48.49
17	294.66	55.87
18	307.40	63.78
19	319.82	72.20
20	331.88	81.12
21	343.56	90.53
22	354.85	100.40
23	365.74	110.73
24	376.19	121.49
25	386.19	132.66
26	395.73	144.24
27	404.79	156.19
28	413.36	168.51
29	421.41	181.16
30	428.95	194.13
31	435.95	207.40
32	442.40	220.94
33	448.30	234.73
34	453.63	248.75
35	458.38	262.98
36	462.55	277.39
37	464.25	284.31

Circle Center At X = 107.0 ; Y = 372.5 and Radius, 368.0

\*\*\* 1.357 \*\*\*

Failure Surface Specified By 32 Coordinate Points

Point No.	X-Surf M	Y-Surf M
--------------	-------------	-------------

1	105.26	35.73
2	120.20	37.15
3	135.07	39.10
4	149.86	41.59
5	164.56	44.60
6	179.13	48.13
7	193.58	52.18
8	207.87	56.74
9	221.98	61.81
10	235.91	67.39
11	249.63	73.45
12	263.12	80.00
13	276.37	87.03
14	289.37	94.53
15	302.08	102.48
16	314.51	110.89
17	326.62	119.73
18	338.42	129.00
19	349.87	138.69
20	360.97	148.77
21	371.70	159.25
22	382.06	170.11
23	392.02	181.32
24	401.57	192.89
25	410.70	204.79
26	419.40	217.01
27	427.67	229.53
28	435.47	242.33
29	442.82	255.41
30	449.70	268.74
31	456.09	282.31
32	456.81	284.00

Circle Center At X = 72.9 ; Y = 454.6 and Radius, 420.1

\*\*\* 1.365 \*\*\*

1

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf M	Y-Surf M
1	74.32	14.16
2	88.70	18.42
3	102.99	22.96
4	117.20	27.77
5	131.32	32.84
6	145.34	38.19
7	159.25	43.79
8	173.05	49.66
9	186.74	55.79
10	200.31	62.18
11	213.76	68.83
12	227.08	75.72
13	240.27	82.87
14	253.32	90.27
15	266.22	97.91
16	278.98	105.80

17	291.59	113.93
18	304.04	122.29
19	316.33	130.89
20	328.46	139.73
21	340.41	148.78
22	352.19	158.07
23	363.80	167.57
24	375.22	177.30
25	386.45	187.24
26	397.50	197.39
27	408.35	207.74
28	419.00	218.31
29	429.45	229.07
30	439.69	240.02
31	449.73	251.17
32	459.55	262.51
33	469.15	274.03
34	478.22	285.34

Circle Center At X = -143.5 ; Y = 775.0 and Radius, 791.4

\*\*\* 1.368 \*\*\*

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf M	Y-Surf M
1	84.63	21.35
2	99.03	25.57
3	113.34	30.06
4	127.55	34.85
5	141.67	39.91
6	155.69	45.25
7	169.60	50.86
8	183.40	56.75
9	197.07	62.91
10	210.62	69.34
11	224.05	76.04
12	237.33	83.00
13	250.48	90.22
14	263.48	97.70
15	276.33	105.44
16	289.03	113.43
17	301.57	121.66
18	313.94	130.15
19	326.14	138.88
20	338.16	147.84
21	350.01	157.04
22	361.67	166.48
23	373.14	176.14
24	384.42	186.03
25	395.50	196.14
26	406.38	206.46
27	417.06	217.00
28	427.52	227.75
29	437.77	238.70
30	447.80	249.86
31	457.61	261.21

32	467.19	272.75
33	476.54	284.48
34	477.14	285.26

Circle Center At X = -121.4 ; Y = 751.7 and Radius, 758.9

\*\*\* 1.373 \*\*\*

1

Failure Surface Specified By 29 Coordinate Points

Point No.	X-Surf M	Y-Surf M
1	136.21	59.65
2	151.09	61.52
3	165.90	63.91
4	180.62	66.81
5	195.23	70.22
6	209.71	74.14
7	224.04	78.55
8	238.22	83.46
9	252.21	88.86
10	266.01	94.74
11	279.60	101.10
12	292.96	107.92
13	306.07	115.20
14	318.92	122.94
15	331.50	131.11
16	343.78	139.72
17	355.76	148.74
18	367.42	158.18
19	378.75	168.02
20	389.73	178.24
21	400.34	188.84
22	410.58	199.80
23	420.44	211.10
24	429.89	222.75
25	438.94	234.71
26	447.57	246.98
27	455.76	259.55
28	463.52	272.39
29	470.42	284.77

Circle Center At X = 89.7 ; Y = 489.4 and Radius, 432.3

\*\*\* 1.400 \*\*\*

Failure Surface Specified By 32 Coordinate Points

Point No.	X-Surf M	Y-Surf M
1	64.00	6.97
2	78.89	5.17

3	93.86	4.14
4	108.85	3.88
5	123.85	4.38
6	138.79	5.65
7	153.65	7.69
8	168.39	10.48
9	182.97	14.02
10	197.34	18.31
11	211.48	23.32
12	225.34	29.05
13	238.89	35.49
14	252.09	42.61
15	264.91	50.39
16	277.32	58.83
17	289.28	67.88
18	300.76	77.54
19	311.73	87.77
20	322.16	98.55
21	332.02	109.85
22	341.30	121.64
23	349.95	133.89
24	357.97	146.56
25	365.33	159.63
26	372.02	173.06
27	378.00	186.82
28	383.28	200.86
29	387.82	215.15
30	391.63	229.66
31	394.70	244.34
32	395.56	249.91

Circle Center At X = 106.5 ; Y = 296.8 and Radius, 292.9

\*\*\* 1.411 \*\*\*



# **List of Program Generated Error Messages**

## R.1 Error Messages

STABLPRO is intended to be error free, assuming that the input data are correctly prepared. To avoid problems when the data have been incorrectly prepared. STABLPRO checks all data, as they are being read in, for consistency with program requirements.

If an inconsistency is found in data submitted, STABLPRO points it out by displaying an error indication. Unless the error is of a nature that demands immediate termination of execution. STABLPRO continues reading data and checking for more errors until a point is reached in execution where termination is required as a consequence of previously determined errors.

The errors are coded and referenced to descriptions in the next section. Each input error has a two digit number prefixed with two letters, associated the error with a particular command or class of errors. The prefixes are listed below.

<b>SQ</b>	Command Sequence errors
<b>FR</b>	Free-form Reader errors
<b>PF</b>	errors associated with command PROFIL
<b>WA</b>	errors associated with command WATER
<b>SF</b>	errors associated with command SURFAC
<b>LM</b>	errors associated with command LIMITS
<b>LD</b>	errors associated with command LOADS
<b>SL</b>	errors associated with command SOIL
<b>AI</b>	errors associated with command ANISO
<b>RC</b>	errors associated with commands RANDOM and CIRCLE
<b>BK</b>	errors associated with command BLOCK
<b>TI</b>	errors associated with command TIES
<b>SP</b>	errors associated with command SPENCR

## R.2 Command Sequence Errors

### *SQ01*

A command other than PROFIL has been used as the first command in the execution sequence. The first command must be PROFIL. PROFIL initialized STABLPRO prior to reading all data pertinent to the definition of a problem. All data that would have been read prior to encountering the first use of command PROFIL would have been nullified and would not have been made available to STABLPRO for the purpose of analyzing the first problem.

### *SQ02*

An attempt to compute the factor of safety of a specified trial failure surface with command EXECUT has been aborted. The isotropic soil parameters describing the soil types of the current problem do not exist. After each use of the command PROFIL in an execution sequence, the isotropic soil parameters of each soil type must be specified by use of command SOIL before command EXECUT may be used. Each time a new problem is introduced in an execution sequence by command PROFIL, the soil parameters describing soil types of preceding problems are no longer available for use.

### *SQ03*

An attempt to compute the factor of safety of an unspecified trial failure surface with command EXECUT has been aborted. After each use of command PROFIL, CIRCLE, RANDOM or BLOCK, a trial failure surface must be specified with command SURFACE before command EXECUT may be used.

### *SQ04*

The command ANISO has been used without the isotropic soil parameters being defined. Anisotropic strength data may not be specified unless the isotropic parameters have been defined by command SOIL after the last use of command PROFIL.

### *SQ05*

An attempt to use one of the commands, RANDOM, CIRCLE, or BLOCK has been aborted. The isotropic soil parameters describing the soil types of the current problem do not exist. After each use of command PROFIL in an execution sequence, the isotropic soil parameters of each soil type must be specified by use of command SOIL before any of the above mentioned commands may be used. Each time a new problem is introduced in an execution sequence by command PROFIL, the soil parameters describing soil types of preceding problems are no longer available for use.

## R.3 Free-form Reader Error Codes

### *FR01*

Data are insufficient to continue execution. An attempt was made to read beyond the last data item specified. Check for missing data items or for gaps between data items on each line larger than one blank space. This error only occurs at the end of an execution sequence within the data provided with the last command used.

### *FR02*

The line of data displayed begins with one or more blank spaces or may be entirely blank. The first item of data of each line is required to be in the first column. Lines entirely blank are not permitted.

### *FR03*

Within the line of data displayed, a decimal point has been detected for a number read as an integer. An integer is not allowed to contain a decimal point. First check if any numbers intended to be integers contain a decimal point. If not, check if error is indirectly caused by a displacement of data read. Causes of displacements are discussed below.

### *FR04*

Within the line of data displayed, a minus sign has been detected for a number read as an integer. All integers are required to be positive. Negative integers are never required as input for STABLPRO. This error may be caused indirectly by displacement of data read. Causes of displacements are discussed below.

Displacements of data read are caused either by inadvertently omitting items of data or by leaving gaps between items of data larger than one blank space. Data items following a gap larger than one blank space are not read. Instead, data from the next line are read in their place, producing a displacement of data read from that point on.

At some point following the displacement, an error will be produced indirectly. A real number might be read as an integer, or vice versa, producing error FR03 or FR06 respectively. A negative real number read as an integer will also produce error FR04. When a displacement occurs, and if none of the above errors are produced, the numeric data will be exhausted and finally a command worked will be read as numeric data producing error FR05 or FR07 depending upon whether an integer or real number was being read.

If cause of displacement is not found in the displayed line of data, check the preceding lines of data.

## R.4 PROFIL Error Codes

### *PF01*

The number of ground surface boundaries exceeds the total number of profile boundaries. The number of profile boundaries must be less than or equal to the total number of profile boundaries.

### *PF02*

The number of profile boundaries specified may not exceed 100. The problem must be either redefined so fewer profile boundaries are used, or the dimensioning of the program must be increased to accommodate the problem so defined.

### *PF03*

A negative coordinate has been specified for the profile boundary indicated. All problem geometry must be located within the 1<sup>st</sup> quadrant.

### *PF04*

The coordinates of the end points of the profile boundary indicated have not been specified in the required order. The coordinates of the left end point must precede those of the right.

### *PF05*

The ground surface boundaries indicated are not properly ordered or are not continuously connected. The ground surface boundaries must be specified from left to right and the ground surface described must be continuous.

### *PF06*

The required subsurface boundary order is unsatisfied for the boundaries indicated. Of boundaries which overlap horizontally, those above the other must be specified first.

## R.5 WATER Error Codes

### *WA01*

An attempt has been made to suppress or reactivate undefined water surface data. Data must be defined by a prior use of command WATER before they can be suppressed. Suppressed data can not be reactivated if command PROFIL has been used in the execution sequence subsequent to their suppression. Command PROFIL nullifies all data prior to their use whether the data are active or suppressed.

**WA02**

The number of points specified to define the water surface exceeds 40. The problem must be either redefined so fewer points are used, or the dimensioning of the program must be increased to accommodate the problem as defined.

**WA03**

Only one point has been specified to define the water surface. A minimum of two points is required.

**WA04**

A negative coordinate has been specified for the water surface point indicated. All problem geometry must be located within the 1<sup>st</sup> quadrant.

**WA05**

The water surface point indicates that it is not to the right of the points specified prior to it. The points defining the water surface must be specified in left to right order.

## **R.6 SURFAC Error Codes**

**SF01**

The number of points specified to define a trial failure surface exceeds 100. The problem must be either redefined so fewer points are used, or the dimensioning of the program must be increased to accommodate the problem as defined.

**SF02**

Only one points has been specified to define the trail failure surface. A minimum of two points is required.

**SF03**

A negative coordinate has been specified for the trial failure surface point indicated. All problem geometry must be located within the first quadrant.

**SF04**

The trial failure surface point indicated is not to the right of the points specified prior to fit. The points defining the trial failure surface must be specified in left to right order, and no two points are allowed to define a vertical line.

*SF05*

The first point specified for the trial failure surface is not within the horizontal extent of the defined ground surface. All pint defining a trial failure surface must be within the horizontal extent of the defined ground surface.

## **R.7 LIMIT Error Codes**

*LM01*

An attempt has been made to suppress or reactivate undefined surface generation boundary data. Data must be defined by a prior use of command LIMITS before they can be suppressed. Suppressed data cannot be reactivated if command PROFIL has been used in the execution sequence subsequent to their suppression. Command PROFIL nullifies all data read prior to their use whether the data are active or suppressed.

*LM02*

The number of surface generation boundaries specified to deflect upwards exceeds the total number of boundaries specified. The number of upward deflecting boundaries must not exceed the total number of boundaries.

*LM03*

The number of surface generation boundaries specified exceeds 20. The problem must be either redefined so fewer surface generation boundaries are used, or the dimensioning of the program must be increased to accommodate the problem as defined.

*LM04*

A negative coordinate has been specified for the surface generation boundary indicated. All problem geometry must be located within the 1<sup>st</sup> quadrant.

*LM05*

The coordinates of the end points of the surface generation boundary indicated have not been specified in the required order. The coordinates of the left end point must precede those of the right.

## **R.8 LOADS Error Codes**

### *LD01*

An attempt has been made to suppress or reactive undefined surcharge boundary loads. Data must be defined by a prior use of command LOADS before they can be suppressed. Suppressed data can not be reactivated if command PROFIL has been used in the execution sequence subsequent to their suppression. Command PROFIL nullifies all data read prior to their use, whether the data are active or suppressed.

### *LD02*

The number of surcharge boundary loads specified exceeds 10. The problem must be either redefines so fewer loads are used, or the dimensioning of the program must be increased to accommodate the problem as defined.

### *LD03*

A negative coordinate has been specified for the surcharge boundary load indicated. All problem geometry must be located within the first quadrant.

### *LD04*

The X coordinates defining the horizontal extend of the surcharge boundary load indicated have not been specified in the required order. The X coordinate of the left end of the load must precede the X coordinate of the right end.

### *LD05*

The surcharge boundary load indicated is not to the right of all the loads specified prior to it or overlaps one or more of them. The loads must be specified left to right and are not allowed to overlap.

## **R.9 SOIL Error Codes**

### *SL01*

The profile boundary indicated with the error message has an undefined soil type index. The number of soil types specified must be greater than or equal to each soil type index which has been assigned to profile boundaries.



*SL02*

The number of soil types may not exceed 20. The problem must be either redefined so fewer soil types are used, or the dimensioning of the program must be increased to accommodate the problem as defined.

*SL03*

An attempt has been made to change the parameters of one or more soil types which are undefined. No soil types have been defined since the last use of command PROFIL. When a new problem is introduced by command PROFIL, the soil parameters, describing soil types of preceding problems in the execution sequence, are no longer available for use and cannot therefore be changed.

*SL04*

The number of soil types to be changed is greater than the total number of soil types already defined. This implies changing isotropic soil parameters of soil types which have not been specified and therefore is not permitted. The number of soil types to be changed must be less than or equal to the number of soil types specified by a previous use of command SOIL. Each soil type must be previously specified, before its parameters may be changed.

*SL05*

An attempt has been made to change the parameters describing an unspecified soil type. The soil type must be defined before it may be modified. The index of each soil type to be changed must be less than the total number of soil types.

## **R.10 ANISO Error Codes**

*AIO1*

An attempt has been made to suppress or reactivate undefined anisotropic strength data. Data must be defined by a prior use of command ANISO before they can be suppressed. Suppressed data cannot be reactivated if command PROFIL has been used in the execution sequence subsequent to their suppression. Command PROFIL nullifies all data read prior to their use whether the data are active or suppressed.

*AIO2*

The number of anisotropic soil types specified may not exceed the number of soil types specified by command SOIL.

**A103**

The number of anisotropic soil types specified exceeds 5. The problem must be either redefined so fewer anisotropic soil types are used, or the dimensioning of the program must be increased to accommodate the problem as defined.

**A104**

The soil type index indicated is greater than the number of soil types specified by command SOIL. The index of each anisotropic soil type must be less than or equal to the number of soil types specified.

**A105**

The number of direction ranges specified for the anisotropic soil type indicated is less than 2 or exceeds 10. No soil type should be defined anisotropic with number of direction ranges less than 2, as this means soil is isotropic. Also no soil type should exceed 10 direction ranges. If this is desired, the dimensions of the program must be increased.

**A106**

The counterclockwise limit of each direction range must be specified in counterclockwise order, if the anisotropic strength is to be properly defined for the anisotropic soil type indicated.

**A107**

The total direction range for the anisotropic soil type indicated has not been completely defined. The counterclockwise limit of the last direction range specified must be 90 degrees.

## **R.11 RANDOM and CIRCLE Error Codes**

**RCO1**

The first initiation point lies to the left of the defined ground surface. The x coordinate of the first initiation point must be specified so all trial failure surfaces generated will intersect the defined ground surface when they initiate.

**RCO2**

The first and last initiation points are not correctly specified. They must be specified in left-right order.

**RCO3**

The last initiation point lies to the right of the defined ground surface. The X-coordinate of the last initiation point must be specified so all trial failure surfaces generated will intersect the defined ground surface when they initiate.

**RCO4**

The right termination limit lies to the right of the defined ground surface. The right termination limit must be specified so all trial failure surfaces generated will intersect the defined ground surface when they terminate.

**RCO5**

The left and right termination limits are not correctly specified. They must be specified in left-right order.

**RCO6**

The last initiation point lies to the right of the right termination limit. It is impossible to successfully generate any trial failure surfaces, when the initiation point lies to the right termination limit.

**RCO7**

The depth limitation for trial failure surface development is negative. The depth limitation must be set at or above the X-axis so the generated trial failure surfaces will not be allowed to develop below it.

**RCO8**

The length specified for the line segments used to generate trial failure surfaces is less than or equal to zero. The length must be greater than zero.

**RCO9**

An initiation point is below the depth initiation. The depth limitation must be set lower to enable the successful generation of trial failure surfaces from all initiation points.

**RC10**

The number Of points defining a generated trial failure surface exceeds 100. The length specified for the line segments must be increased.

**RC11**

200 attempts to generate a single trial failure surface have failed. The search limitations are either *too* restrictive, or they actually prevent successful generation of a trial failure surface from one or more of the initiation points. Check and revise the search limitations or use an alternative trial surface generator.

**RC12**

Fewer than 10 trial surfaces have been specified to be generated. A minimum of 10 must be generated

**RC13**

The angle specified as clockwise direction limit for surface generation is larger than the angle specified as counterclockwise direction limit. This is not correct. Check to see if angles have been reversed.

**RC16**

The choice of using Janbu's empirical coefficient (0 or 1) was incorrectly done.

**RC17**

If the Janbu empirical coefficient is being used, the soil case was chosen incorrectly. i.e.. not equal to one of the following integers 1, 2, 3.

## **R.12 BLOCK Error Codes**

**BK01**

The number of boxes specified for a sliding block search exceeds 10. The problem must be either redefined so fewer points are used, or the dimensioning of the program must be increased to accommodate the problem as defined.

**BK02**

The length specified for the line segments used to generate the active and passive portions of the trial failure surfaces is less than or equal to zero. The length must be greater than zero.

**BK03**

The two coordinate points specified to define the centerline of the box indicated have not been specified correctly. The left point must be specified first.

**BK04**

The box indicated and the one specified before it are not properly ordered, or they overlap. All boxes must *be* specified in left to right order and the boxes are not allowed to overlap one another.

**BK05**

The box indicated is wholly or partially defined outside of the 1st quadrant. All problem geometry must be located within the 1st quadrant.

**BK06**

The box indicated is wholly or partially above the defined ground surface. Each box must be defined totally below the ground surface.

**BK07**

It is not possible to complete the active portion of the failure surface from part of or all of the last box specified. The last box specified must be entirely to the left of the right end of the defined ground surface.

**BK08**

It is not possible to complete the passive portion of the failure surface from part of or all of the first box specified. The first box specified must be entirely to the right of a fictitious line extended downward at forty-five deg with the horizontal from the left end of the defined ground surface.

**BK09**

The number of points defining a generated trial failure surface exceeds 100. The length specified for the line segments of the active and passive portions of the generated trial failure surfaces must be increased.

*BK10*

200 attempts to generate a single trial failure surface have failed. The search limitations are either too restrictive or they actually prevent successful generation of a trial failure surface. Check and revise the search limitations or use an alternate trial surface generator.

*BK11*

Fewer than 10 trial failure surfaces have been specified to be generated. A minimum of 10 must be generated.

*BK12*

The point(s) calculated on active or passive portion of the sliding block is not within the horizontal extent of the defined ground surface. Either the specified boxes should be changed or the geometry of the problem should be extended to include the point(s) in question.

*BK16*

The choice of using Janbu's empirical coefficient (0 or 1) was incorrectly done.

*BK17*

If the Janbu empirical coefficient is being used, the soil case was chosen incorrectly, i.e., not equal to one of the following integers 1, 2, 3.

## **R.13 TIES Error Codes**

*TIO1*

An attempt has been made to suppress or reactivate undefined tieback loads. Data must be defined by a prior use of command TIES before they can be suppressed. Suppressed data can not be reactivated if command PROFIL has been used in the execution sequence subsequent to their use, whether the data are active or suppressed.

*TIO2*

The number of tieback loads specified exceeds 10. The problem must either be redefined so fewer tieback loads are used, or dimensioning of the program must be increased to accommodate the problem as defined.

*TIO3*

A negative coordinate has been specified for the tieback load indicated or the calculated Y coordinate of the end of the tieback is negative. All problem geometry must be located within the first quadrant.

*TIO4*

The inclination limits have been exceeded for the tieback load indicated. The inclination of a tieback load must be equal to or greater than zero deg and less than 180 deg as measured clockwise from the horizontal.

*T105*

The point of application of the tieback load specified does not lie on the ground surface boundary specified. Check the boundary Lumber specified and the X and Y coordinates of the point of application of the tieback load indicated.

*T106*

The horizontal spacing between tiebacks for the row of tieback is indicated is incorrect. The horizontal spacing between tiebacks must be greater than or equal to 1 ft (or 1 meter if using SI units).

*T107*

The length of the tieback indicated is incorrect. The length of a tieback must be greater than or equal to zero (ft). Zero is used for loads other than tieback type of loads.

## **R.14 SPENCR Error Codes**

*SP01*

An incorrect value for the approximate slope angle has been specified. The slope angle specified must be greater than zero (deg) and less than 90 (deg).

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