S D P S

Surface Deformation Prediction System
for Windows
version 5.2

Quick Reference Guide and Working Examples

by

Dr. Zacharias Agioutantis and Dr. Michael Karmis
Department of Mining and Minerals Engineering
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061-0239

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The purpose of this guide is to provide a quick reference guide to the SDPS for windows (version 5.x) suite of programs and to develop working experience through the application of examples. This guide is not designed to be a tutorial in ground control engineering or in subsidence engineering. It is assumed that the user is already familiar with the basic principles of ground deformation prediction and pillar stability evaluation.

As of version 5.1, the SDPS suite of programs includes the Pillar Stability Analysis programs (ALPS and ARMPS) developed by NIOSH.

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w	the panel width; the minimum dimension of a panel
h	panel depth; the vertical distance between the mining horizon and the surface; also known as the overburden thickness
m	the seam thickness; the extraction thickness (note that the extraction thickness may be different than the seam thickness)
R	the extraction ratio
R*	the adjusted extraction ratio
d	the distance of the inflection point from the rib (a positive value indicates that the position of the inflectionpoint is inby); also referred to as the “edge effect”
β	the influence angle
r	the influence radius
Smax	the maximum subsidence
a	the maximum subsidence factor
Bs	the strain coefficient
%HR	the percent hardrock in the overburden
Wp	the pillar width
Hp	the pillar height
Wo	the opening width

Chapter 1: Introduction

The original Surface Deformation Prediction System (SDPS) programs were developed by the Department of Mining and Minerals Engineering, Virginia Polytechnic Institute and State University (Virginia Tech), Blacksburg, VA, USA, in 1987, under the leadership of Dr. Michael Karmis. At the time, the SDPS suite of programs was developed as a research tool, rather than an integrated approach to the prediction of surface deformations. They were based on field studies and the prediction methods were adapted to eastern U.S. mining and geological conditions.

The SDPS software has since been modified and updated, in order to facilitate user interaction and has been transformed from a research methodology to an engineering tool for the field engineer and the mine planning team. The previous version (version 4.x), was designed to provide an integrated approach to the problem of calculating and predicting ground deformations above undermined areas. Based on empirical or site-specific regional parameters, the operator was able to calculate a variety of ground deformation indices, according to one or more numerical formulations.

Additionally, it should be noted that version 4.x of the SDPS package was also enhanced by an independent module used to calculate pillar stability, based on four well accepted pillar strength formulations. This tool was provided in an effort to help the operator evaluate the stability of pillars in room-and-pillar mines.

SDPS version 4.x was written for the DOS environment and provided pull down menus, mouse support and context sensitive help. It was limited by the DOS limitations, such as the need for special peripheral (printer, plotter, etc.) drivers, as well as by the infamous 640KB limit on program size and data arrays.

Funding for the SDPS related work, leading to version 4.x, was provided by various federal and state agencies, the mining industry and Virginia Tech.

SDPS version 5.x constitutes the latest update of SDPS software, developed specifically for the Microsoft Windows® environment (SDPS for Windows). In this respect, all programs fully utilize the central management of computer resources (i.e. memory, use of the clipboard, peripherals, etc.) provided by the Microsoft Windows®. All SDPS version 5.x programs are developed in the Visual Basic 6.0 programming language (professional edition).

The development of the Windows version of SDPS (version 5.x) was performed by Dr. Michael Karmis and Dr. Zach Agioutantis under a contract from the Office of Surface Mining, Reclamation and Enforcement. Software development was supervised by Dr. Zach Agioutantis. Version 5.0 was released in December, 1998.

The authors would like to acknowledge the technical comments, discussions and suggestions of Dr. Jesse Craft, Geologist, Dr. Kewal Kohli, Mining Engineer and Ms.

Lois Uranowski, Environmental Engineer, Appalachian Regional Coordinating Center, Office of Surface Mining, Reclamation and Enforcement.

Additional thanks are due to Ms. Ann Stewart-Murphy, Mr. Steven J. Schafrik, and Mr. David A. Newman for technical comments and for troobleshooting different routines of the SDPS programs.

The SDPS (version 4.x) and SDPS for Windows (version 5.x) software are marketed by Carlson Software under a licensing agreement from Virginia Tech Intellectual Properties.

Carlson Software may be contacted by:

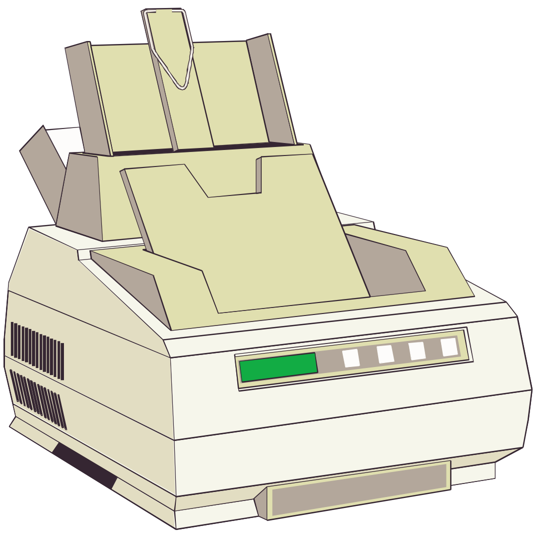
- phone: (606) 564-5028
- fax: (606) 564-6422
- e-mail: info@carlsonsw.com
- internet: http://www.carlsonsw.com
- post Carlson Software,
102 West 2nd St.,
Suite 200,
Maysville,
KY 41056, USA

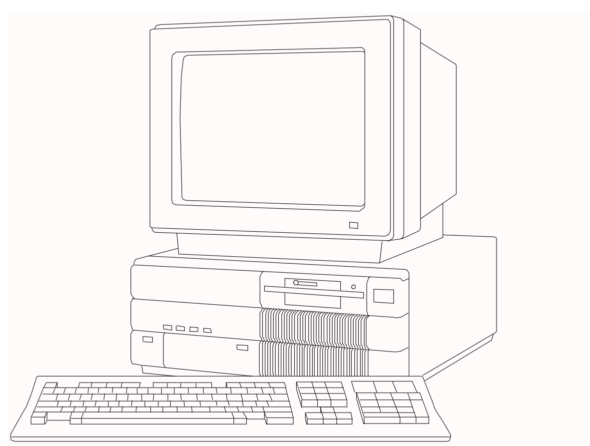
1.1 Requirements

The hardware and operating system requirements for installing the SDPS suite of programs are shown in Table 1.1.1.

Table 1.1.1: System requirements for the SDPS suite of programs

Suggested	**Minimum**
Windows 95 / 98 / NT4 / 2000	Windows 95 / NT3.51
Pentium based unit	80486DX based unit
SVGA interface, 1024x768, 256 colors	VGA interface, 800x600, 16 colors
15MB disk space	7MB disk space
Laser printer or color inkjet printer	Any printer supported by windows
Adobe Acrobat Reader (to read this tutorial in electronic format)	



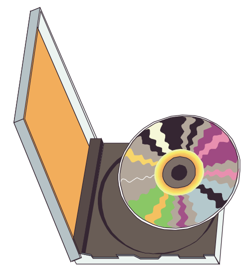


1.2 Installing / UnInstalling SDPS

SDPS for Windows (version 5.x) covers all 32bit platforms such as Windows 95, Windows 98, as well as the Windows NT series (WinNT 3.51, WinNT 4.0, etc.).

1.2.1 Installing from a CDROM

Insert the CDROM in the appropriate drive and locate the single executable file on the root directory which contains the letters SDPS (i.e. SDPS51.EXE or SDPS52.EXE, etc.). Double-click on the appropriate installation file as described previously. Note that if the autorun feature of the CDROM drive is enabled, installation may start automatically. Follow the prompts of the installation package. For convenience select the default settings.



You may optionally install the Adobe Acrobat Reader software, which included in the distribution media for your convenience. To do this, double click on the appropriate file (e.g. AR302.EXE, AR405.EXE, etc.). You may obtain the latest version of the latter product through the internet (www.adobe.com) free of charge.

1.2.2 Installing from diskettes

Insert the first diskette in the appropriate drive and locate the single executable file on the root directory which contains the letters SDPS (i.e. SDPS50.EXE or SDPS51.EXE, etc.). Double-click on the appropriate installation file as described previously. Follow the prompts of the installation package. For convenience select the default settings.

Note that the Adobe Acrobat Reader is not distributed in the diskette version.

1.2.3 Registration

When the SDPS package is first installed then upon execution of any program module, the indication "Demo version" will be visible. Also, the main picture in each module will be overwritten by bright red letters. When the package is registered, these messages do not appear. To **register** the product, execute the main SDPS module and click on the "Register" button. Enter the user name and note the license code generated by the program. Contact the supplier of the program for a license key. Enter the license key and click on "Save License". Once registration is successful, the registration button on the main menu will be disabled.

1.2.4 Uninstalling

To **uninstall** the SDPS software, switch to the installation directory, i.e. "c:\Program Files\SDPS for Windows", and then switch to the "SETUP" directory within the installation directory. Run the SETUP.EXE program in that directory and follow the prompts.

Optionally you may also uninstall the program by executing the "Add/Remove Programs" icon in the "Control Panel" directory of your Windows platform.

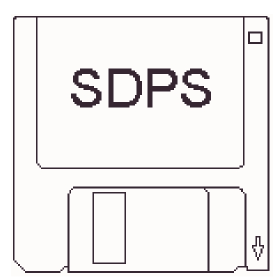
1.3 SDPS Software Overview

Table 1.3.1 explains the function of each of the programs included in the SDPS package.

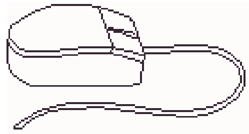
Table 1.3.1: Files distributed with SDPS

SDPS.EXE	Main Menu Program
PROF.EXE	Profile Function Program
INFL.EXE	Influence Function Main Program
INFLSOLV.EXE	Influence Function Calculation Module (should not be executed in stand-alone mode)
GRAF.EXE	Graphing Program
PILL.EXE	Pillar Stability Program
ALPS.EXE	Analysis of Longwall Pillar Stability Program
ARMPS.EXE	Analysis of Retreat Mining Pillar Stability
SDPS.HLP	SDPS Help File (may be accessed as stand-alone and through the programs)
QREF.PDF	Quick Reference Guide (requires Acrobat reader from Adobe)

Note:
The individual application programs may be executed as stand-alone or through the SDPS main menu program.



1.4 SDPS Features



Menu System
- Pull-down menus
- Easy to use input forms
- Check boxes, option buttons, command buttons, combo boxes
- Integrated graphics
- Metric and imperial (English) units
- Context sensitive help (one help file for all programs)
- General program options (settings)
- Custom program options
- Standard file selection dialog
- Standard print dialog

File System
- ASCII files
- Custom path support for data files
- Redefinable file extensions
- Multiple line description for each project

Peripherals
- Integrates seamlessly with devices supported by the Windows environment

1.5 General Configuration of the SDPS Programs

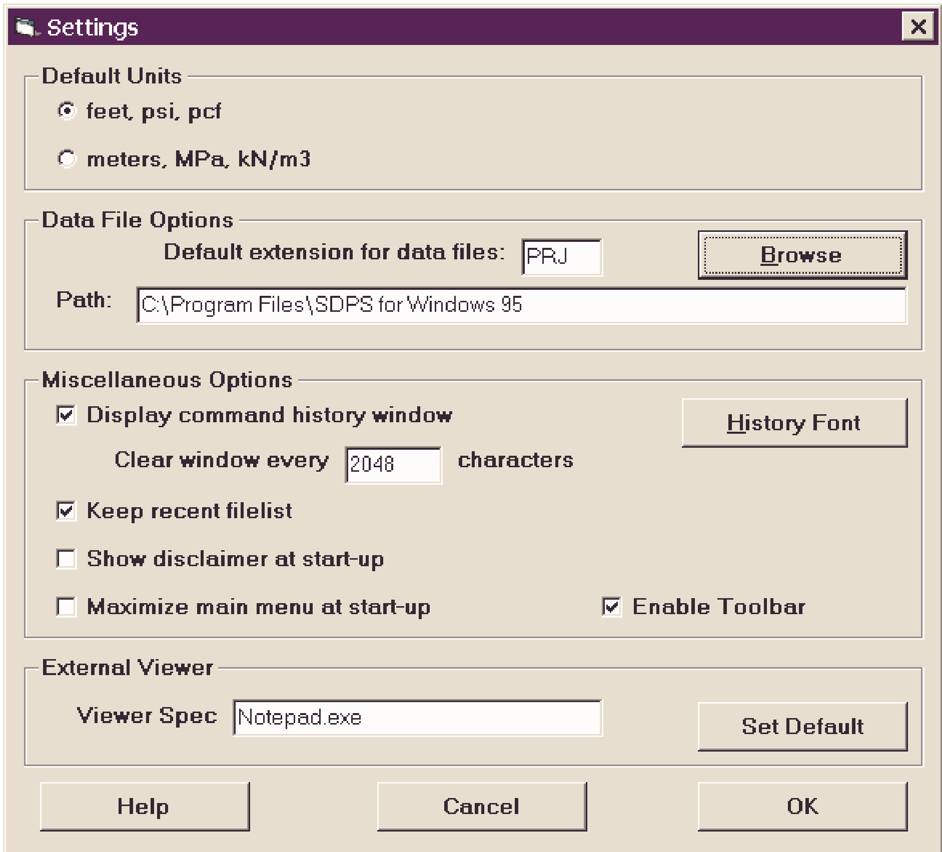


Figure 1.5.1: General configuration options

The general configuration options for the profile function module are shown in Figure 1.5.1. To invoke this form select the menu item **Utilities-Settings**. The default settings for all modules are managed using similar forms.

In this form the user can select the default units, the default 3-letter extension for data files, the default path for data files, and other options such as displaying a command history window, keeping a recent file list, enabling the toolbar, specifying an external viewer for viewing large ASCII report files, etc.

1.6 Custom Configuration of the SDPS Programs

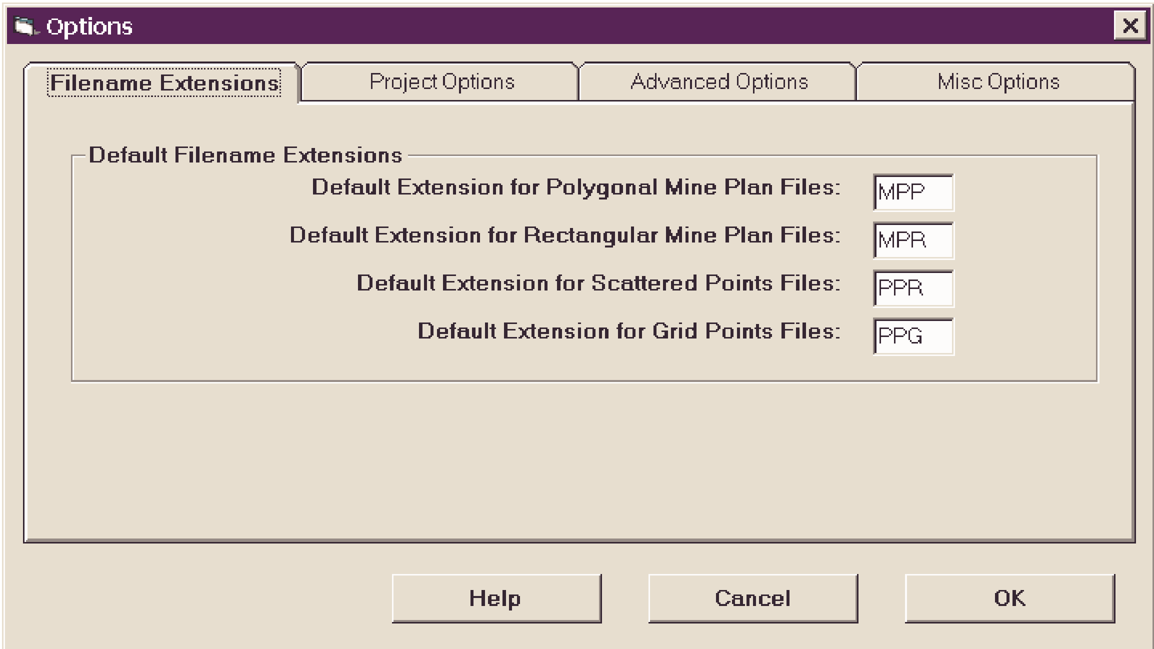


Figure 1.6.1: Example of custom configuration options

Each module has its own custom configuration options. As an example, the custom options for the influence function module are shown in Figure 1.6.1. To invoke this form select the menu item **Utilities-Options**.

1.7 Overview of Subsidence Parameters

Maximum Subsidence Factor

The values of maximum subsidence factor, as function of the width-to-depth ratio and the percent hardrock in the overburden, are shown in the supercritical subsidence factor tables for longwall panels and for room-and-pillar panels respectively. When using the profile function method, the subsidence factor is calculated for the actual width-to-depth ratio of the panel. For example, for a panel with W/h = 0.8 (subcritical) and %HR = 50% the subsidence factor is equal to 0.38.

When using the influence function method, the technique requires knowledge of the supercritical subsidence factor, which will subsequently be adjusted through the superposition concept by the program itself. For example, for a panel with W/h = 0.8 (subcritical) and %HR = 50% the subsidence factor is found for W/h = 1.5 (supercritical) and equal to 0.40.

Notes:

A panel is considered supercritical for W/h greater than 1.2. Due to numerical approximations there may be slight variations to the supercritical subsidence factors presented in the supercritical subsidence factor tables.

Inflection Point

The location of the inflection point from the rib, with respect to overburden depth (d/h), can be estimated based on two empirical curves (see the Inflection Point Diagram). Both curves were statistically generated from the available field data. The first is an average curve based on a least squares estimator, while the second is considered an envelope or conservative curve in the sense that it tends to overpredict the surface impact of a given excavation area. In essence, this means that for average data the predicted subsidence profile could be either inside or outside of the measured subsidence line, whereas for conservative (envelope) data, an attempt is made to keep the prediction lines outside the measured ones, i.e. overestimate the influence of the mined area to the surface.

From experience and constant validation of the programs, the authors recommend that, for Appalachian predictions, improved accuracy is obtained by using the following rule: determine the d/h ratio using the conservative curve for subcritical panels (W/h < 1.2) determine the d/h ratio using the average curve for supercritical panels (W/h >= 1.2).

Notes:

Always use the actual width-to-depth ratio.

Angle of Influence

The angle of principal influence (β, beta) is one of the basic parameters used in the influence function method since it has a major impact on the distribution of the deformations on the surface. It is measured in degrees from the horizontal and the average value determined for the Appalachian coalfields is beta=67 deg. The parameter required for these calculations is the tangent of this angle (i.e. tanβ = 2.31). The angle of influence is related to the radius of influence as shown in the equation:

$$\tan\beta = \frac{h}{r}$$

where
h = the overburden depth
r = the radius of influence

This value should be determined for each site by fitting a calculated subsidence profile to a measured subsidence profile. If this is not possible, the influence angle can be approximately set as the complementary angle to the angle of draw.

Supercritical Subsidence Factor Tables
The supercritical subsidence factors used in the calculations are presented in Tables 1.7.1 and 1.7.2.

Table 1.7.1: Calculation of maximum subsidence factors (Smax/m) for longwall panels

	Percent Hardrock in the Overburden							
W/h	10%	20%	30%	40%	50%	60%	70%	80%
0.6	0.64	0.59	0.51	0.42	0.34	0.26	0.21	0.16
0.7	0.69	0.63	0.55	0.46	0.36	0.28	0.22	0.18
0.8	0.71	0.65	0.57	0.47	0.38	0.29	0.23	0.18
0.9	0.72	0.66	0.58	0.48	0.38	0.30	0.23	0.19
1.0	0.73	0.67	0.58	0.49	0.39	0.30	0.24	0.19
1.1	0.74	0.68	0.59	0.49	0.39	0.31	0.24	0.19
1.2	0.74	0.68	0.59	0.49	0.39	0.31	0.24	0.19
1.3	0.74	0.68	0.60	0.49	0.40	0.31	0.24	0.19
1.4	0.75	0.69	0.60	0.50	0.40	0.31	0.24	0.19
1.5	0.75	0.69	0.60	0.50	0.40	0.31	0.24	0.19
1.6	0.75	0.69	0.60	0.50	0.40	0.31	0.24	0.19
1.7	0.75	0.69	0.60	0.50	0.40	0.31	0.24	0.19
1.8	0.75	0.69	0.60	0.50	0.40	0.31	0.24	0.19
1.9	0.76	0.69	0.60	0.50	0.40	0.31	0.24	0.19
2.0	0.76	0.69	0.60	0.50	0.40	0.31	0.24	0.19

Table 1.7.2: Calculation of maximum subsidence factors (Smax/(m R*)) for high extraction room-and-pillar panels

	Percent Hardrock in the Overburden							
W/h	10%	20%	30%	40%	50%	60%	70%	80%
0.6	0.52	0.48	0.42	0.35	0.28	0.22	0.17	0.13
0.7	0.57	0.53	0.46	0.38	0.30	0.24	0.19	0.15
0.8	0.60	0.55	0.48	0.40	0.32	0.25	0.19	0.15
0.9	0.61	0.56	0.49	0.41	0.32	0.25	0.20	0.16
1.0	0.62	0.57	0.49	0.41	0.33	0.26	0.20	0.16
1.1	0.62	0.57	0.50	0.41	0.33	0.26	0.20	0.16
1.2	0.63	0.58	0.50	0.42	0.33	0.26	0.20	0.16
1.3	0.63	0.58	0.51	0.42	0.34	0.26	0.20	0.16
1.4	0.64	0.58	0.51	0.42	0.34	0.26	0.21	0.16
1.5	0.64	0.59	0.51	0.42	0.34	0.26	0.21	0.16
1.6	0.64	0.59	0.51	0.42	0.34	0.26	0.21	0.16
1.7	0.64	0.59	0.51	0.43	0.34	0.27	0.21	0.16
1.8	0.64	0.59	0.51	0.43	0.34	0.27	0.21	0.17
1.9	0.64	0.59	0.51	0.43	0.34	0.27	0.21	0.17
2.0	0.64	0.59	0.52	0.43	0.34	0.27	0.21	0.17

Horizontal Strain Factor

The value of this factor is directly related to the magnitude of the calculated strains and curvatures over an undermined area. It can be empirically estimated by the average ratio of measured strain and curvature over a set of surface points.

The average value determined for the Appalachian coalfields is:

$$Bs = (0.35 \pm 0.05)\ \frac{h}{\tan\beta}$$

where h is the excavation depth and tanβ is the influence angle. The horizontal strain factor is expressed in units of length. The horizontal strain coefficient is unitless and its default value is 0.35.

Note: The higher the value for this coefficient, the larger the predicted strains and displacements.

Chapter 2: The Profile Function Method

2.1 Overview of the Profile Function Method

A profile function defines the distribution of subsidence values on the surface along an axis orthogonal to the boundary of a theoretical, infinitely long, underground excavation (Figure 2.1.1). In general, a function which is asymptotic to two horizontal lines is required, and the parameters to be used for this equation must be determined from field data. The prediction model used in this formulation is based on the hyperbolic tangent formulation as shown in the equation:

$$s(x) = \frac{1}{2} S_{max} \left\{ 1 - \tanh\left(\frac{cx}{B} \right) \right\}$$

where:

S(x)	=	subsidence at x;
x	=	distance from the inflection point;
Smax	=	maximum subsidence of the profile;
B	=	distance from the inflection point to point of Smax; and
c	=	constant.

This model is sensitive to the maximum subsidence factor for the area (Smax) and the distance of the inflection point from the rib. The maximum subsidence factor can be calculated as a function of the percentage of hard material in the overburden (percent hardrock). The position of the inflection point can be calculated as a function of the overburden depth. Both estimations are based on statistical procedures used to evaluate data from Eastern U.S. coalfields and should be used for predicting subsidence movements over areas with similar characteristics.

In this profile function formulation, the magnitude of the maximum subsidence factor is not affected by the position of the inflection point. Thus, the same maximum subsidence factor is obtained using either an average or a conservative estimate of the position of the inflection point. The position of the inflection point, however, determines the distribution of the subsidence profile with respect to the rib of the excavation. It should be emphasized that the profile function developed for this area may not be applicable for subsidence predictions over other coalfields with different characteristics.

Notes:

- The width-to-depth ratio (W/h) should be greater than 0.5 in order to conform with the limits of the database used to generate the empirical parameters of this profile function.

- Due to the mathematical nature of the hyperbolic tangent function, slight variations in the magnitude of the calculated maximum subsidence value (Smax) might occur for different panel widths, under supercritical conditions. In other words, although the calculated maximum subsidence value should be the same for supercritical conditions, a slight increase in the value of Smax is observed with increasing width-to-depth ratio within the supercritical range. Such variations introduce a margin of error of less than one percent (1%).

- The type of the profile function and its parameters can not be modified by the user.

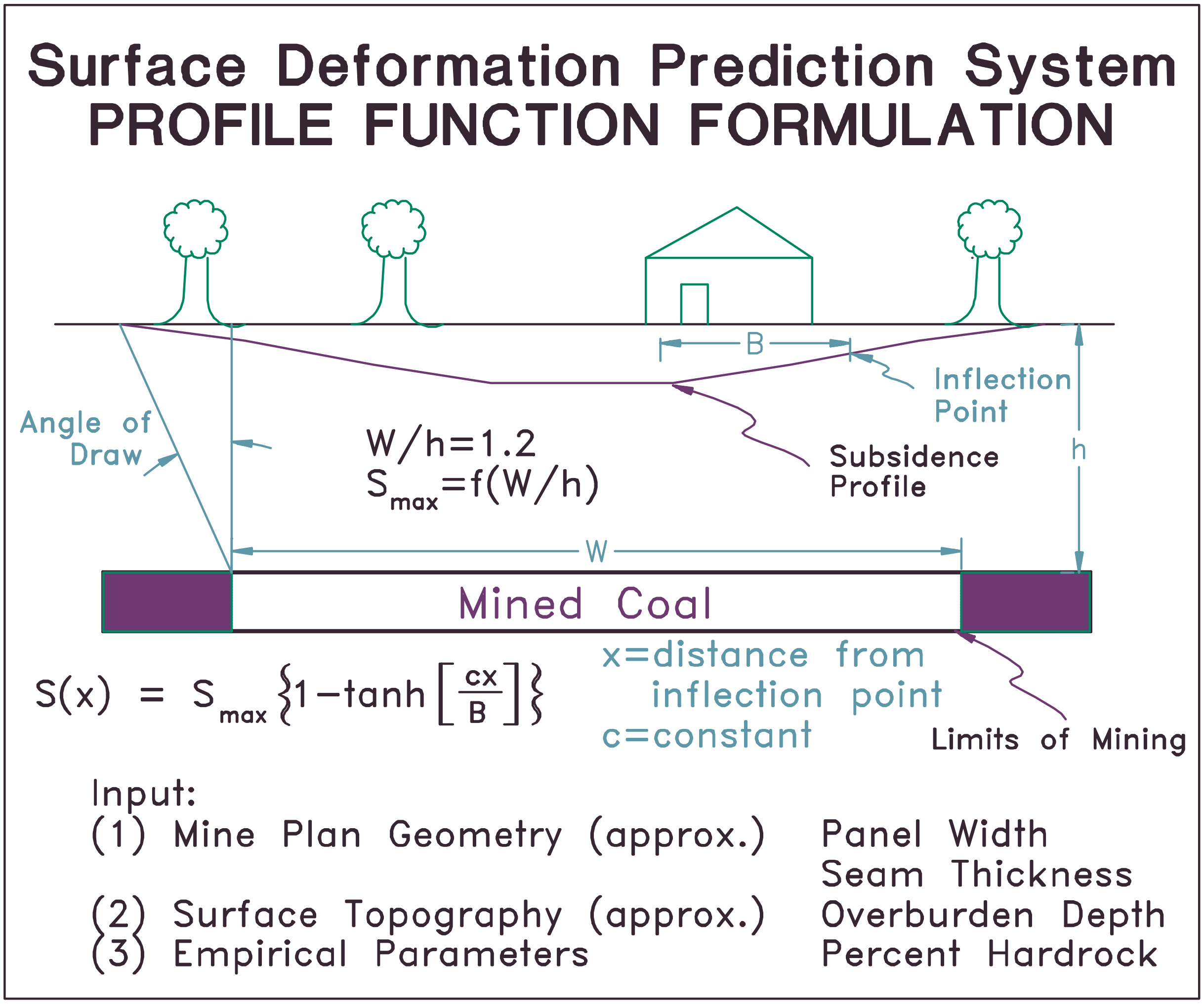


Figure 2.1.1: Definition of terms used in the profile function method

2.2 Example #1: Calculations Using the Profile Function Program

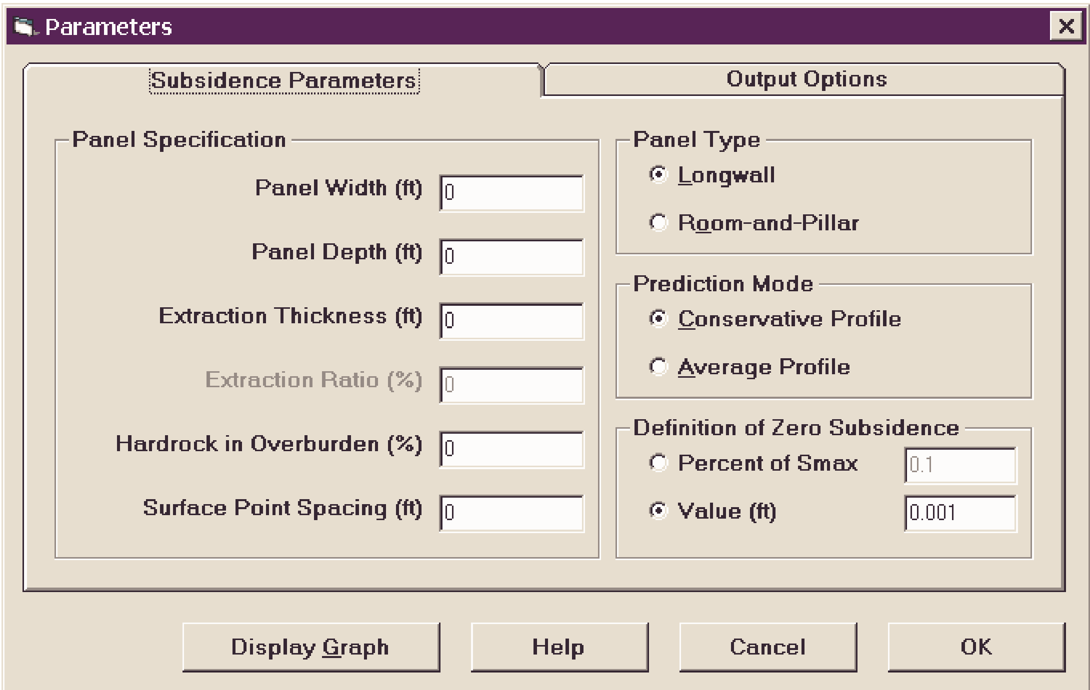


Figure 2.2.1: Profile function input form (part 1)

Instructions

1. Execute the Profile Function module.
2. Select the **Edit - Input Parameters** option (Figure 2.2.1).
   a. Enter the following parameters:
   b. panel type = Longwall
   c. panel width = 600 ft
   d. panel depth = 500 ft
   e. extraction thickness = 5 ft
   f. percent hardrock = 50 %
   g. surface point spacing = automatic (value of 0)
   h. calculation mode = Conservative
3. Select **Conservative Profile** as **Prediction Mode.**
4. Define "Zero Subsidence" either as a percent of the calculated maximum subsidence value for the panel or as an absolute number (i.e. 0.001 ft or 0.01 m).
5. Click on the "Output Options" tab.
6. Select **Display Graph** as **Results Mode** (Figure 2.2.2).Select **Single Curve** as **Graph Mode.**
7. Select the **Display Graph** button to calculate subsidence and plot the results.
8. The graphing option allows comparison up to 6 graphs. To append more curves, the user should either minimize the graph window or move it to the side to expose the Parameters form. Select **Append Curve** as **Graph Mode.**
9. Click on the "Subsidence Parameters" tab. Select **Average Profile** as **Prediction Mode.**
10. Ensure that more than one curves are selected in the **Graph Options** (see "Setting the Graph Options in the next Section).
11. Select the **Display Graph** button to

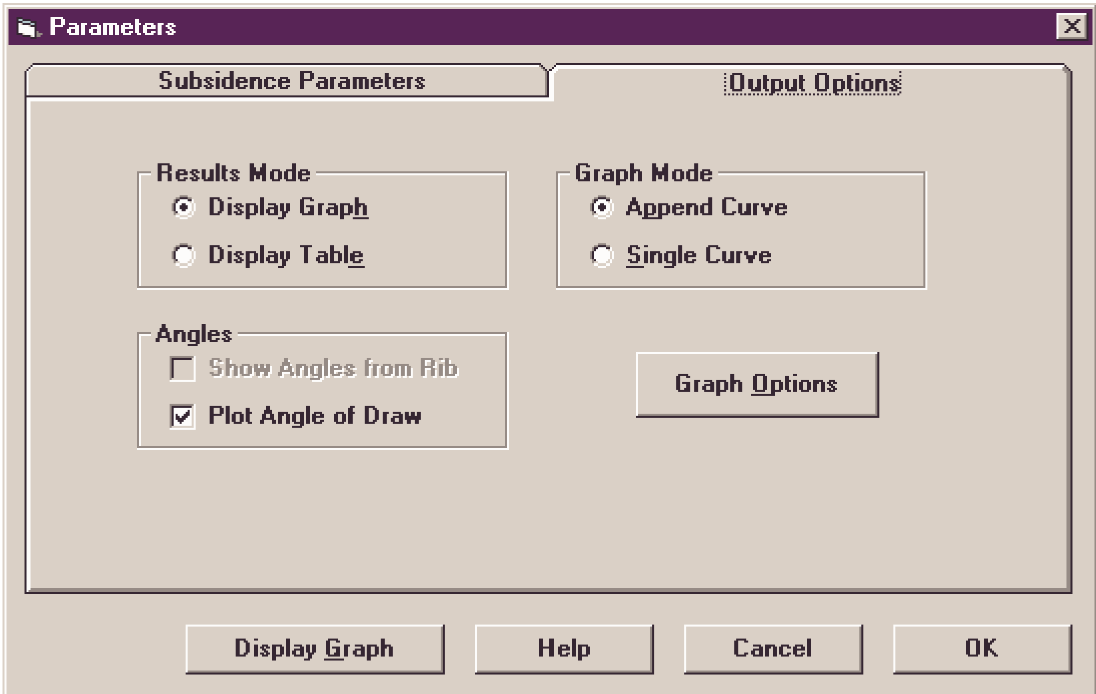


Figure 2.2.2: Profile function input form (part 2)

calculate subsidence and plot the results. Two curves should appear on the graph. Curve #1 corresponds to the first curve plotted and Curve #2 to the second curve plotted. In other words, blue corresponds to the conservative calculation and black corresponds to the average calculation (Figure 2.2.3).

12. Click on the OK button to exit the input form.
13. Select the **File - Save** option to save the input data. Enter EX1 at the file selection dialog box. The data should be saved as EX1.PRF. Select the **Save** button to save the data.
14. Select **Edit - Project Parameters.** Change the **Zero Subsidence Value** to **0.01** ft.
15. Select **Conservative Profile** as **Prediction Mode.**
16. Select **Display Graph** as **Results Mode.**
17. Select **Append Curve** as **Graph Mode.**
18. Select the **Display Graph** button to calculate subsidence and plot the results.
19. Select **Average Profile** as **Prediction Mode.**
20. Select the **Display Graph** button to calculate subsidence and plot the results. Two curves should appear on the graph. Curve #1 corresponds to the first curve plotted and Curve #2 to the second curve plotted (Figure 2.2.4). Compare the graphs on Figures 2.2.3 and 2.2.4.
21. Exit the program and return to the calling environment.

Notes:

When a graph has already been created with the **Plot Angle of Draw** option enabled, then the user can **not** disable the latter option. This is to avoid plotting a graph with multiple curves with and without angle of draw lines. To change this option, clear the graph first and then re-plot it.

If the user need to extend the calculation further out from the angle of draw, then the spacing of the surface points should be increased to create more points on the flat portion of the curve. This is helpful if the user needs to emphasize that a structure lies well outside of the point of zero subsidence.

Copying a Graph:
The user can copy the graph to any windows word processor that supports clipboard functions To accomplish this follow these steps:

1. copy the graph to the clipboard using the **Edit - Copy** menu option in the graph form
2. enable the word processing application (either launch it or maximize it from the taskbar)
3. paste the graph in the application
4. save the file for future reference or report generation
5. add more graphs in the same file

Further Practice:
After completing this original exercise the user may experiment by changing the values one at a time to compare the changes in the curves and the angle of draw values.

Note for the Novice:
It is a good idea to sketch the mineplan on a piece of graph paper before using this program.

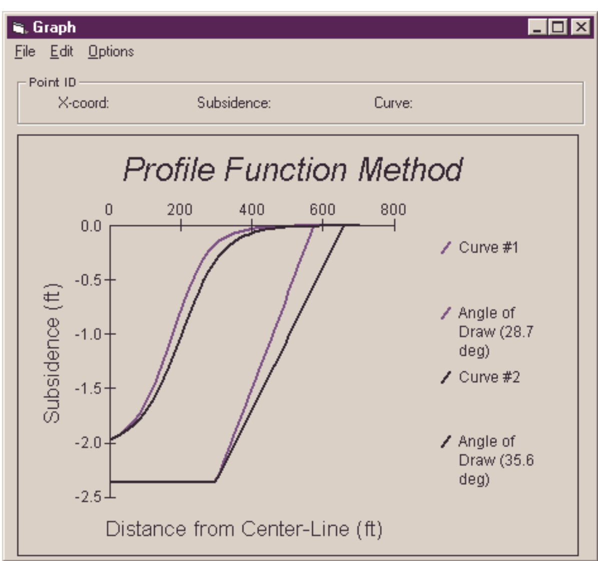


Figure 2.2.3: Plot of conservative and average profile. Also the panel halfwidth and angle of draw are shown (zero subsidence value = 0.001 ft)

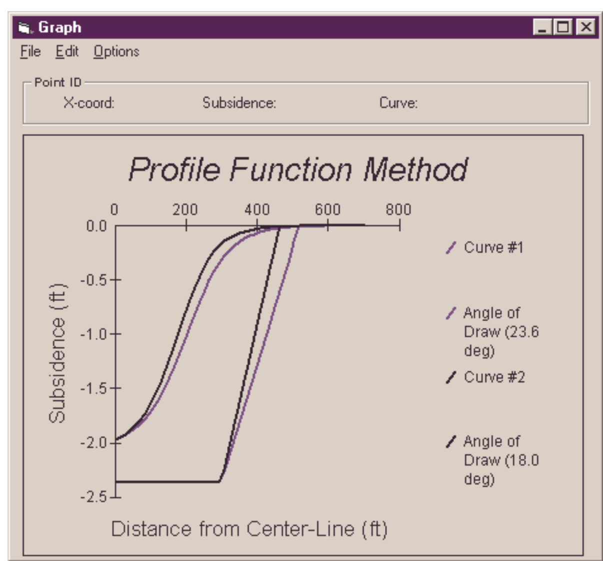


Figure 2.2.4: Plot of conservative and average profile. Also the panel halfwidth and angle of draw are shown (zero subsidence value = 0.01 ft)

2.3 Example #2: Setting the Basic Graph Options - Profile Function Method

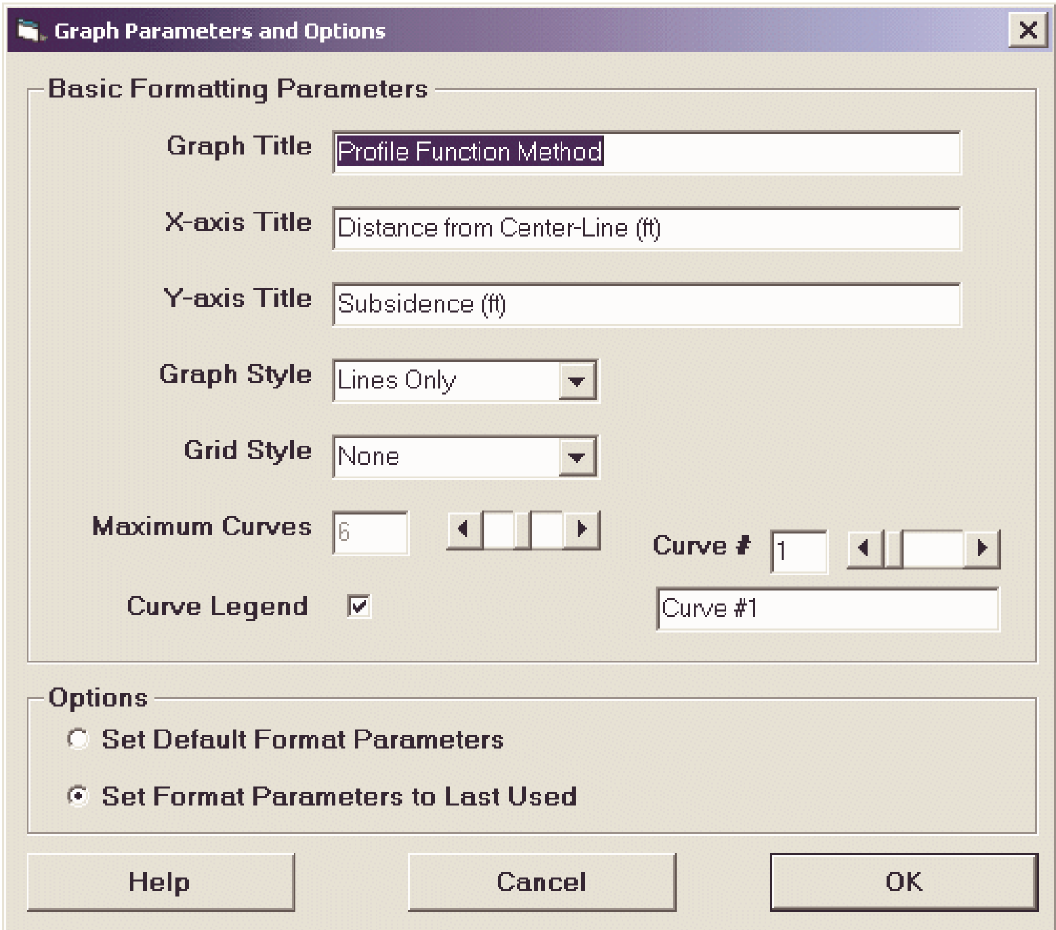


Figure 2.3.1: Graph options for the profile function module

The user can set some basic graph formatting options using the controls in the form shown in Figure 2.3.1. To show this form, the user can either click on the **Graph Options** button in the **Parameters** form (Figure 2.2.1), or click on the **Options - Basic Options** menu item of the graph form (Figures 2.2.2 or 2.2.3).

The parameters included in the **Graph Options** form are as follows:

1. **The graph title**: The graph title is a text string placed over the graph.
2. **The graph x-axis title**: The x-axis title is a text string placed below the x-axis of the graph.
3. **The graph y-axis title**: The y-axis title is a text string placed to the left of the y-axis of the graph.
4. **The grid style**: Four grid styles are available: Horizontal lines, vertical lines, horizontal and vertical lines, no grid lines.
5. **The graph style**: Three graph styles are available: lines, symbols, lines and symbols.

6. When a graph style containing symbols is selected, the user can set the size of the symbol through the scroll bar provided.
7. **Maximum number of curves**: The user can specify the maximum number of curves that can be overlaid on the graph. When this number is exceeded (in the Append Curve mode) the program will instruct the user to clear the graph before proceeding.
8. **Curve legend**: This option enables or disables the legend box in the graph. When this option is enabled, the user can set the legend for each curve in the text box provided. This text box in not enabled when the Curve Legend option is disabled.
9. **Default parameter options**: There are two default parameter options: a) to set the default parameters (i.e. graph title, x-axis title, etc.) every time the graph options form is invoked, and b) to set the format parameters to used in the previous graphing session. These values are saved in the PROF.INI file.

Notes:
Similar options appear in the graph menus of the pillar analysis module as well as the graph module.

Further Practice
Advanced graph options can be accessed through the graph tool bar as explained in Example #3.

2.4 Example #3: Working with the Advanced Graphics Options - Profile Function Method

Figure 2.4.1: The Graph Toolbar (to enable the graph toolbar and the advanced graphics options, click on the Options - Graph ToolBar menu item)

When the graph toolbar is enabled (Figure 2.4.1), then the user has access to powerful graphics functions as provided by the Graphics Server module (version 4.53).

The buttons enabled in the graph tool bar are follows:

- Data
- Titles
- Axis
- Fonts
- Markers
- Background
- System
- Help
- About

An example of using these advanced options is given below. In this example, the user is prompted to change the attributes of certain features of a graph.

A. Changing line attributes:

To accomplish this, click on the **Markers** button (the ninth button from the left, with a green X on it). Then follow these steps:

✓ To change the color of individual lines do the following:

- Move to the box with the line graphs and use the little arrow to select a line.
- Move the cursor to the "Color" box and click on the down arrow, scroll down and select the desired color for the first line. Go back to the graph lines and select the same original color and repeat the color selection.
- Move to the bottom and click on the **Apply Now** button. At this point the color for one set (subsidence curve and angle of draw lines) has changed.
- Experiment with changing the color for the other set of lines.

✓ To change the appearance of the line other than color, do the following.

- In the line box click on **Thick** and click on the scroll button. The second line down is a thin line. Click on different line values to determine which is the best for the current presentation. Repeat this selection for each line set. Therefore, it is possible to make a distinction between calculations by using line width.

- Optionally, select a different line pattern by clicking on the Pattern box and selecting a different line pattern. Once again this has to be done for each line set.

B. Changing tick marks:

To accomplish this, click on the **Axis** button (the sixth button from the left). Then do the following:

- In the “Tick Mark” box click on minor.
- In the “Apply to Axis box” click on “Y Primary” or “X” to apply the tick marks to the graph.
- Click on **Apply Now** to modify the graph.

Note that the user can define the spacing of the secondary ticks. Spacing of primary ticks is automatically adjusted by the Graphics Server object.

C. Print the graph:

To accomplish this, click on the **Systems** button (the fourth button from the right). Then do the following:

- Under printing click on “color” (for color plots).
- Click on **Print** to send the graph directly to the default Windows printer.

D. Changing the background:

To accomplish this, click on the **Background** button (the fifth button from the right). In this menu you can select different colors for different parts of the graph. Optionally, select the position of the different parts of the graph.

E. Changing the fonts:

To accomplish this, click on the **Fonts** button (the eighth button from the left). In this menu the user can select different typeface types, as well as character size for each of the different parts of the graph.

Notes:

The graph template provided by the Graphics Server Object is a function that allows the user to save a custom set of settings, e.g. color, fonts, etc., and recall that template every time that is needed. To accomplish this, make all necessary formatting changes to a graph, and then click on the **System** button. Enter a name in the Graph Template File name text box and click on Save. To restore settings saved in a graph template, create the graph, click on the **System** button, enter the file name of the graph template in the appropriate box and click on Load.

Further instruction on the Graphics Server Object:

Click on the **Help** (?) button of the graph toolbar and follow the prompts.

Chapter 3: The Influence Function Method

3.1 Overview of the Influence Function Method

Influence function methods for subsidence prediction have the ability to consider any mining geometry, to negotiate superposition of the influence from a number of excavated areas having different mining characteristics and, also, to calculate horizontal strains as well as other related deformation indices. The function utilized in SDPS is the bell-shaped Gaussian function. This method assumes that the influence function for the two-dimensional case is given by:

$$g(x,s) = \frac{S_o(x)}{r} \exp\left[-\pi \frac{(x-s)^2}{r^2}\right]$$

where:

r	=	the radius of principal influence = h / tan(beta);
h	=	the overburden depth;
beta	=	the angle of principal influence;
s	=	coordinate of the point P, where subsidence is considered;
x	=	coordinate of the infinitesimal excavated element; and
So(x)	=	convergence of the roof of the infinitesimal excavated element.

Subsidence at any point P(s), therefore, can be expressed by the following equation:

$$S(x,s) = \frac{1}{r} \int_{-\infty}^{+\infty} s_o(x) \exp\left[-\pi \frac{(x-r)^2}{r^2}\right]$$

where:

So(x)	=	m(x) a(x);
m(s)	=	extraction thickness; and
a(x)	=	roof convergence (subsidence) factor.

The influence function formulation can thus be applied to calculate surface deformations (subsidence, strain, slope, curvature, displacements) above longwall and room-and-pillar panels, given the geometry of the excavation, information on the overburden geology, as well as the location of the prediction points on the surface. More specifically, the required data include:

- the geometry of the mine plan and the associated properties (extraction thickness, subsidence factor for supercritical conditions)

- the location (coordinates) of the points on the surface for which prediction of the deformation indices (subsidence, strain, slope, curvature, horizontal displacement) is to be performed
- the empirical parameters that numerically represent the behavior of the overburden

The typical steps required to calculate surface deformations using the influence function method, are shown below. The corresponding flowchart is also shown in Figure 3.1.1. Figure 3.1.2 presents a schematic diagram for creating the input data. Figure 3.1.3 presents typical distributions for the deformation indices that can be calculated by the influence function method. Table 3.1.1 shows all the indices that can be calculated by the influence function method.

✓ Load the Influence Function Program
✓ Input Data
✓ Mine Plan Data
  - Prediction Point Data
  - Empirical Parameters
✓ Select calculation options
  - Subsidence
  - Horizontal Strain
  - Horizontal Displacement
  - Slope
  - Curvature
✓ Save Project File
✓ Calculate Surface Deformations
✓ Load Graphing Program
✓ View Calculated Deformations

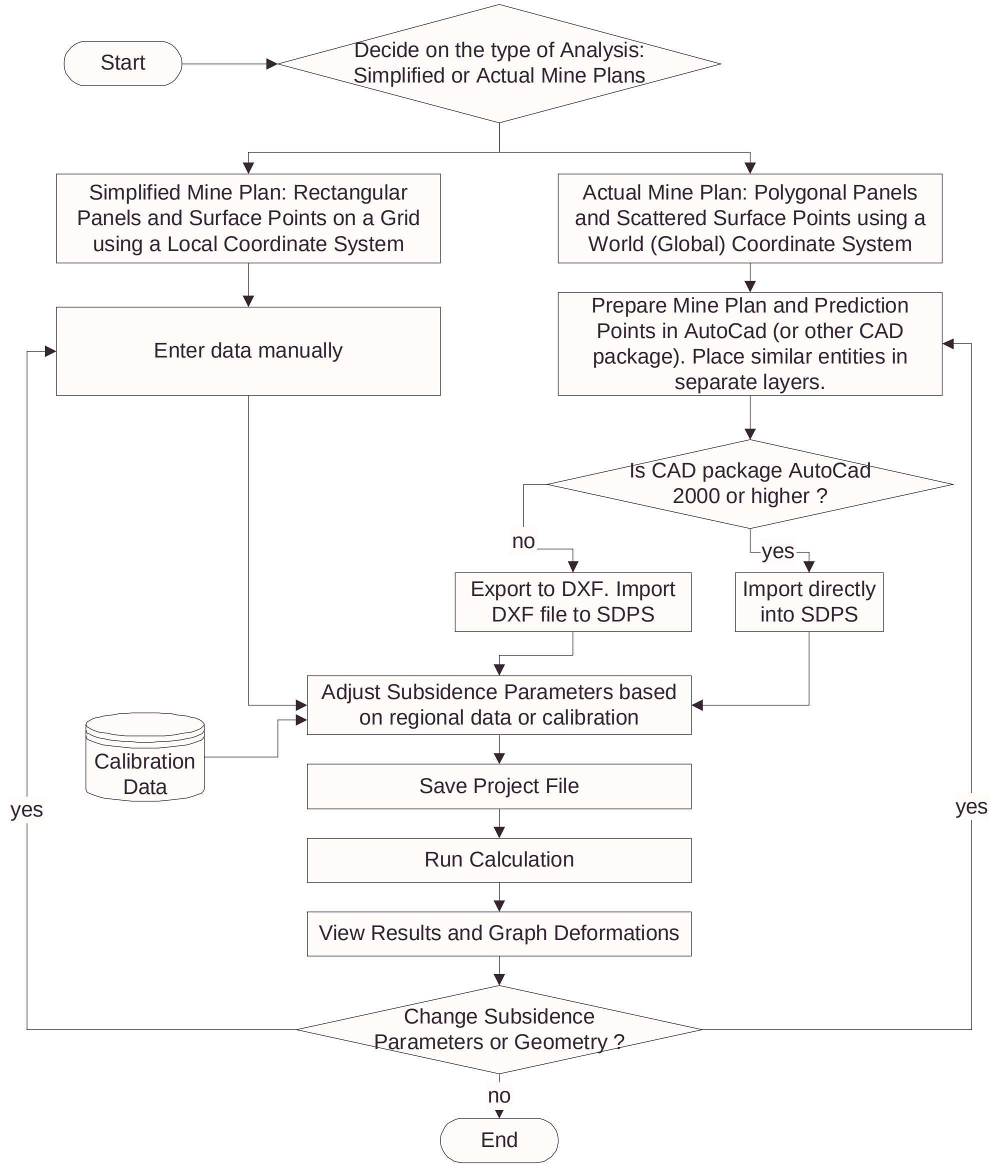


Figure 3.1.1: Flowchart diagram for using the influence function module

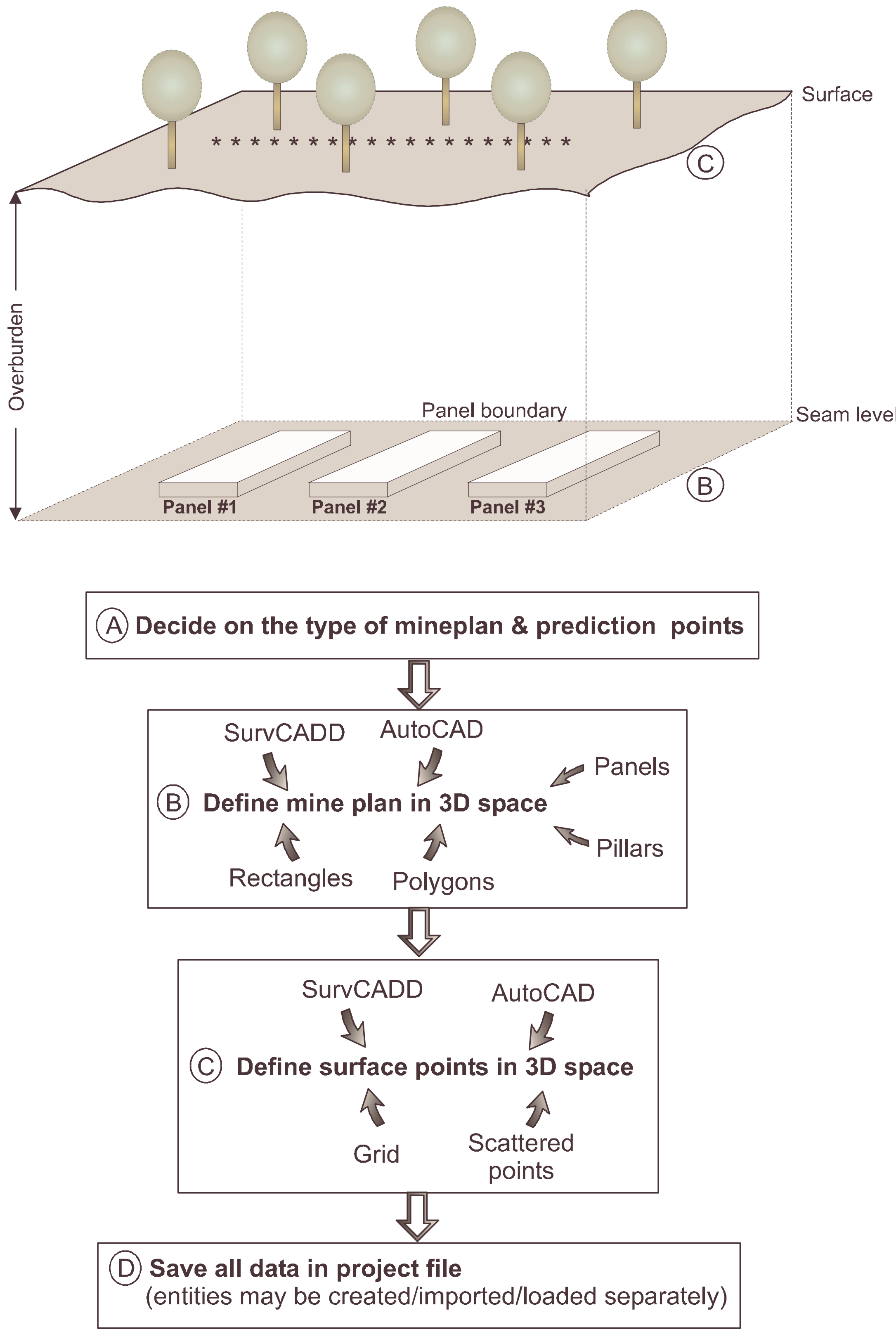
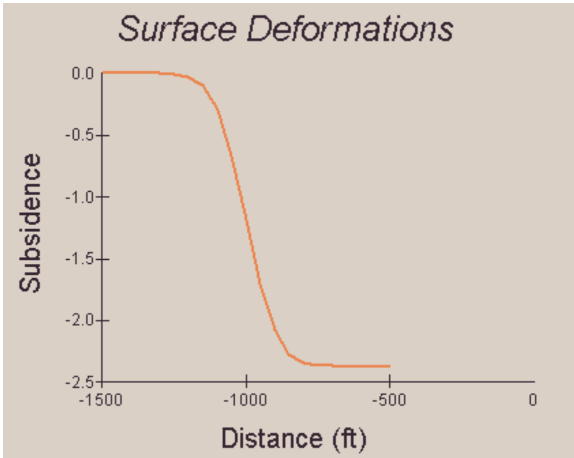
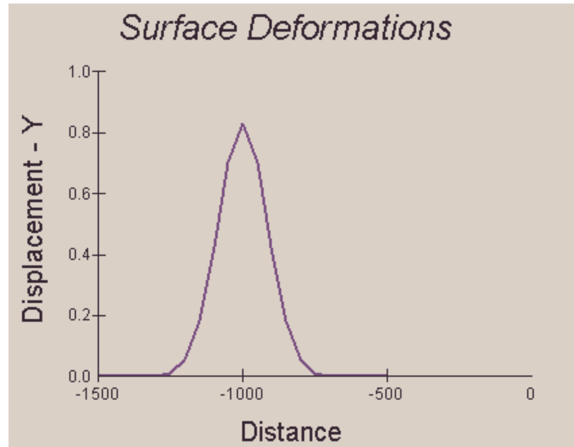
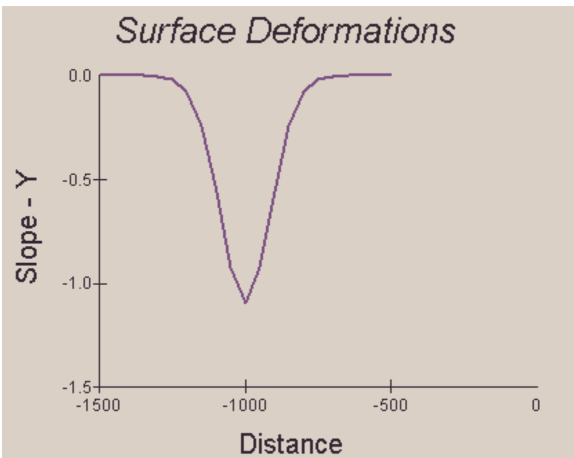


Figure 3.1.2: Steps in defining a project file







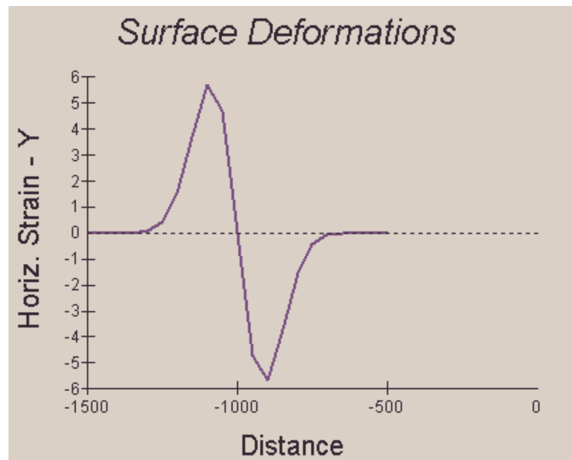


Figure 3.1.3: Typical deformation distributions

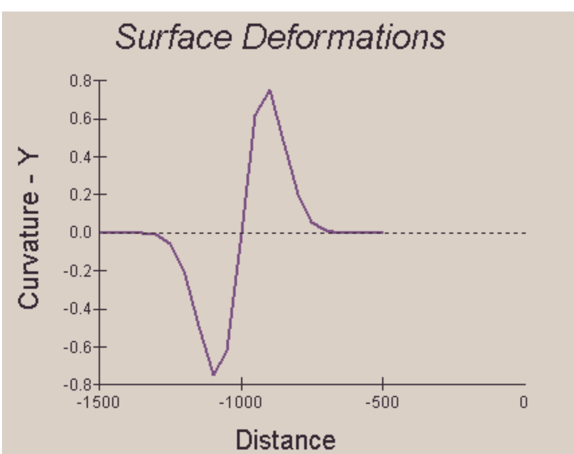


Table 3.1.1: Identification codes for deformation indices

Number	Deformation Index Name	Code	Units
1	Subsidence	SU	ft or m
2	Slope in the X-direction	TX	%
3	Slope in the Y-direction	TY	%
4	Directional Slope	TA	%
5	Maximum (Total) Slope	TM	%
6	Angle[1] of Maximum Slope	TE	deg
7	Horizontal Displacement in the X-direction	VX	ft or m
8	Horizontal Displacement in the Y-direction	VY	ft or m
9	Directional Horizontal Displacement	VA	ft or m
10	Maximum (Total) Horizontal Displacement	VM	ft or m
11	Angle[1] of Maximum Horizontal Displacement	VE	deg
12	Curvature in the X-direction	KX	1/ft or 1/m [2]
13	Curvature in the Y-direction	KY	1/ft or 1/m [2]
14	Directional Curvature	KA	1/ft or 1/m [2]
15	Maximum Principal Curvature	K1	1/ft or 1/m [2]
16	Minimum Principal Curvature	K2	1/ft or 1/m [2]
17	Maximum Curvature	KM	1/ft or 1/m [2]
18	Angle[1] of Maximum Principal Curvature	KE	deg
19	Horizontal Strain in the X-direction	EX	- [3]
20	Horizontal Strain in the Y-direction	EY	- [3]
21	Directional Horizontal Strain	EA	- [3]
22	Maximum Strain	EM	- [3]
23	Maximum Principal Strain	E1	- [3]
24	Minimum Principal Strain	E2	- [3]
25	Angle[1] of Maximum Principal Strain	EE	deg

[1] This angle is calculated in degrees from the positive x-axis in a counter-clockwise direction. It gives the direction of the maximum value of the corresponding index on the x-y plane.

[2] expressed in tenths of ppm (divide by 10.000 to obtain result)

[3] expressed in millistrains (divide by 1000 to obtain result)

3.2 Definition of the Mine Plan in the Influence Function Program

Mine plan data describe the extraction area under consideration using various conventions. An extraction area is always defined in three-dimensional space by specifying the X,Y,Z coordinates of the points defining that area. Mine panels and pillars are referred to as excavation parcels. A parcel can be either active or not active. A parcel, which is not active, is not deleted from the file, but it does not participate in the calculations.

Geometry and Boundary Adjustment:

The geometry of a mine plan is determined by the geometry of the excavation panels adjusted by the edge effect. This parameter represents the distance between the actual rib of the excavation and the position of the inflection point, as determined by panel geometry and site characteristics. The location of the inflection point, which defines the transition between horizontal tensile and compressive strain zones, is very important for the application of the influence function method. The distance of the inflection point from the rib using either an average and a conservative estimate as a function of the width-to-depth ratio of a panel can be estimated using this graph.

Thus, the magnitude of the edge effect can be determined as follows:

✓ from the graph estimating the location of the inflection point for the conservative or average estimate (Figure 3.1.1),

✓ by clicking on the *Subs.Parm* button in the rectangular mine plan form of the influence function program,

✓ by analyzing subsidence curves measured at a specific site or region.

Panel Representation:

✓ Simple mine layouts can usually be approximated using sets of rectangular extraction areas. In this case, the input required for every parcel includes the parcel number; the coordinates of the west, east, south, and north borders; the seam elevation; the extraction thickness (mining height); and the average supercritical subsidence factor (in percent) associated with it. These coordinates can be specified in a local or a global coordinate system with axes parallel to the parcel sides. In the Influence function module, this option is implemented as **Rectangular Mine Plans.**

✓ Complex mine layouts can usually be approximated by a closed polygon (i.e. a piece-wise linear shape). In this case, the input required for every point within a parcel includes the point reference number; the northing (Y), easting (X), and elevation (Z); the extraction thickness (mining height); and the supercritical subsidence factor (in percent) associated with it. The mine plan editor can provide access to all points in a parcel, add new points, and add new parcels provided that the current parcel is defined by three or more points. The points should be entered in a counter-clockwise fashion. The location of each point should be adjusted to reflect the edge effect, or the relative position of the inflection point. The maximum number of parcels and points per parcel can be adjusted within the limits of the available memory. In the Influence function module, this option is implemented as Polygonal Mine Plans.

Warning:

Pillars can not exist outside extracted areas. If a pillar is defined outside an extracted area the results are unpredictable. Currently, the parcel definition module of the program can not check for such inconsistencies. Examples of erroneous panel definitions are given in Appendix 3.

Notes:

- ✓ If no adjustments are made to the geometry of the mine plan, the program assumes that the inflection point is over the rib of the excavation.
- ✓ The user must specify whether each parcel represents an extracted panel or a pillar within an extracted panel. A pillar is mathematically represented as a parcel with a negative subsidence factor. Setting the pillar option on a parcel will reset the subsidence factor associated with this parcel. In that sense, an extraction area can be either positive (i.e. longwall panel) or negative (i.e. pillar in the middle of a panel). Thus, a mine plan that consists only of pillars (without an extraction boundary) will produce a mathematically positive! subsidence.
- ✓ It should be emphasized that the subsidence factor used here is the subsidence factor for supercritical conditions.
- ✓ The reason for supporting more than one format for input data is for the user's convenience. For example, certain panels or pillars can be easily represented as rectangles and can be entered as single entities, compared to four or more entries required if these panels are digitized point by point. Additionally, calculations for rectangular parcels are much faster compared to calculations for parcels defined by individual points.

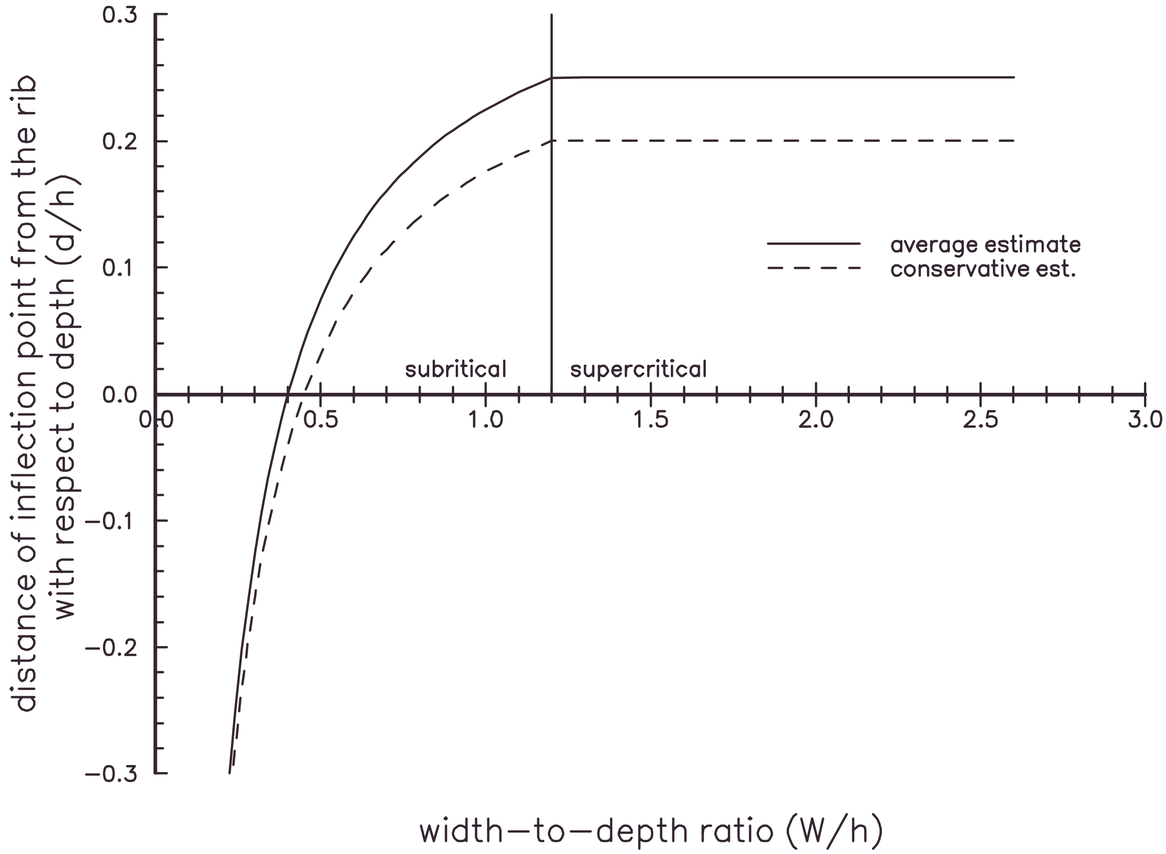


Figure 3.2.1: Determination of the offset of the inflection point.

3.3 Definition of the Prediction Points in the Influence Function Program

Prediction point data describe the surface points where the deformation indices will be calculated. Prediction points are always defined in three-dimensional space, by specifying the X,Y,Z coordinates of these points. A point can be either active or not active. A point which is not active is not deleted from the file but will not be included in the calculations.

Scattered Points

A scattered point set may consist of any number of points that are randomly located on the surface. If such points can be specified as part of a grid, then the Grid Points option should be used. Required parameters for each point include:

- ✓ the point reference code which can be any alphanumeric string,
- ✓ the easting, northing and elevation of each point,
- ✓ the point status, i.e. active or not active (an inactive point will not be displayed in the View option and will not participate in any of the calculations)

Grid Points

A grid point set may consist of any number of points in a window. This window is defined by minima and maxima in the X- and Y- directions as well as the cell size in each direction.

The grid can only be oriented parallel to the current coordinate system. If the grid needs to be oriented at an angle to the current coordinate system, the grid points should be generated by a different tool and imported as scattered points into the Influence Function module.

The user has two options regarding grid elevations.

- ✓ to consider a flat surface and specify a uniform elevation for all points, and
- ✓ to consider each point on an individual basis and specify individual point elevations.

3.4 Example #4: Calculations Using the Influence Function Program - Deformations on a Transverse Line

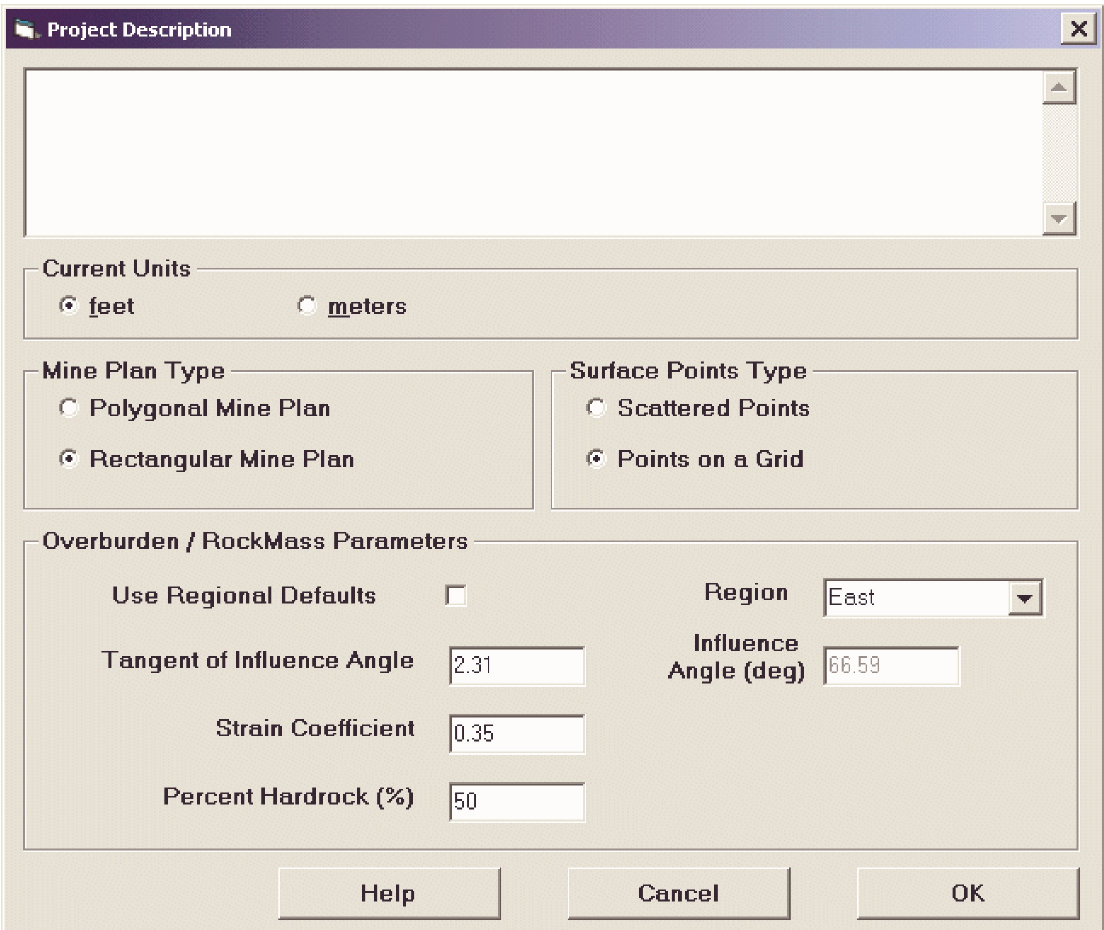


Figure 3.4.1: Project description form

Instructions

1. Execute the Influence Function module.
2. Select the **Edit - Project Description** option (Figure 3.4.1).
3. Enter the following parameters:
    - rectangular mine plan
    - grid points
    - angle of influence = 2.31
    - strain coefficient = 0.35
    - percent hardrock = 50%
4. Click on the OK button to exit the input form.
5. Select the **Edit - MinePlan** option (Figure 3.4.2).
6. Enter the following parameters:
    - parcel number = 1.01 (automatic)
    - west border = -300 ft
    - east border = +300 ft
    - south border = -1000 ft
    - north border = +1000 ft
    - seam elevation = 0 ft
    - extraction thickness = 6 ft
    - supercrit. subs. factor = 39.5 % (automatic)
    - parcel status = active panel
    - adjustments = do not adjust

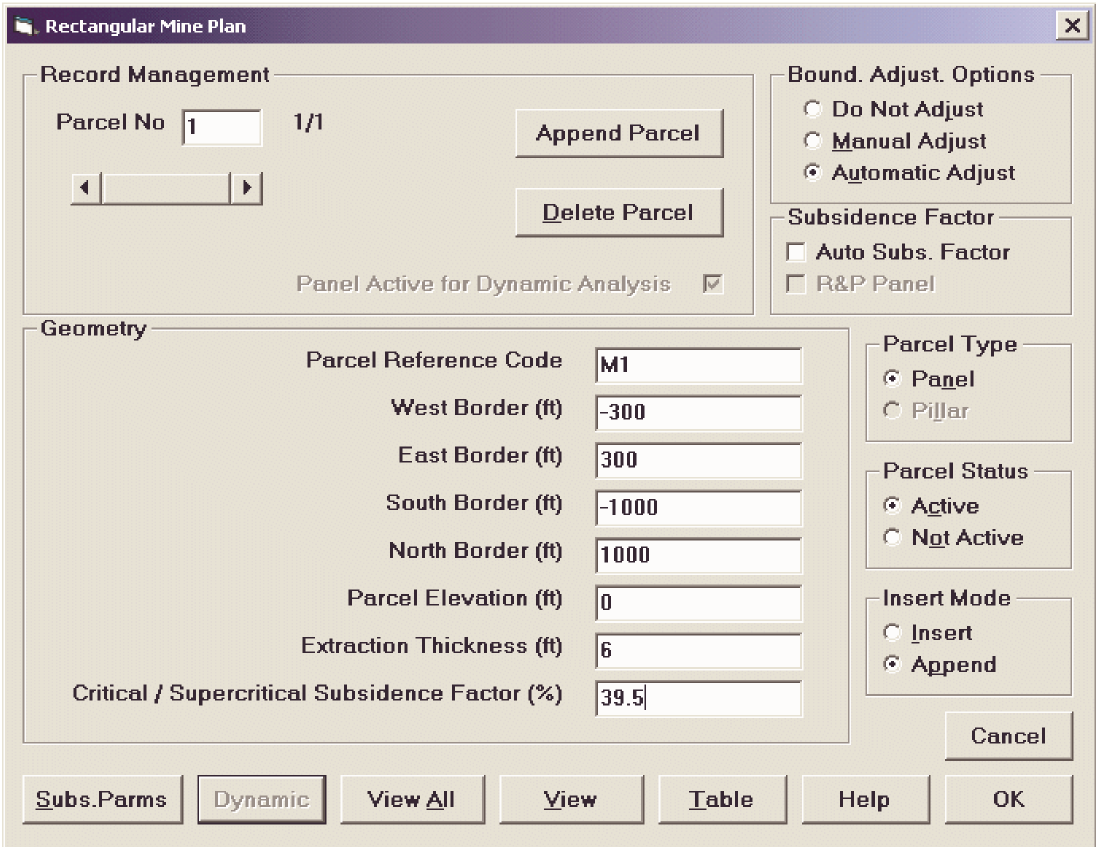


Figure 3.4.2: Rectangular mine plan input form

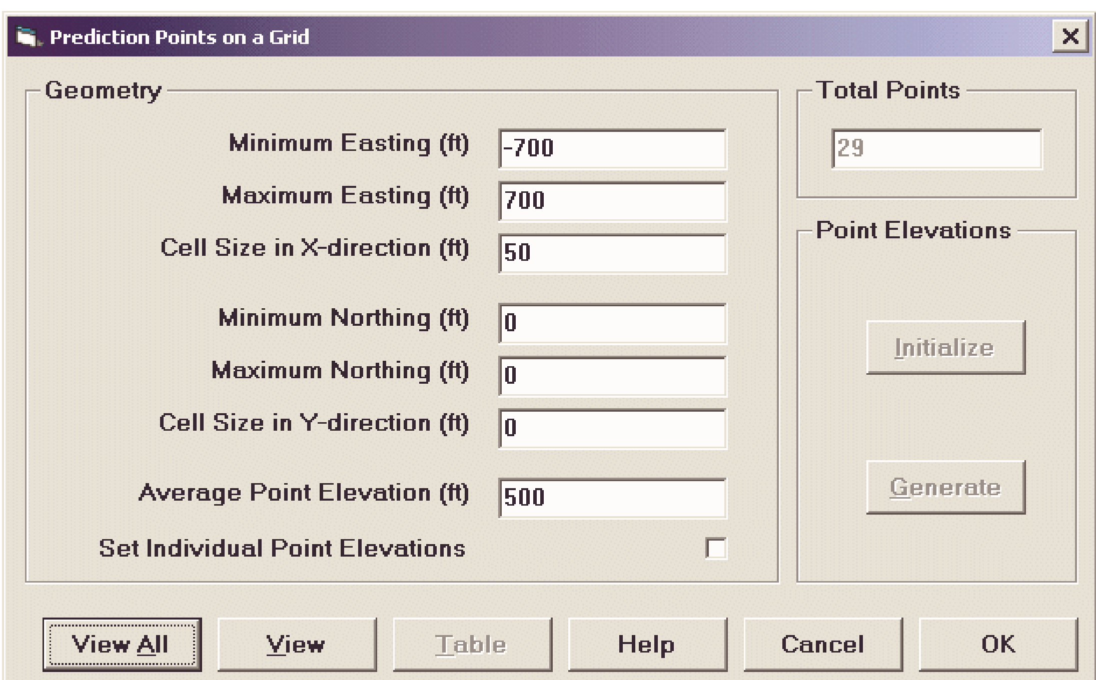


Figure 3.4.3: Grid point input form

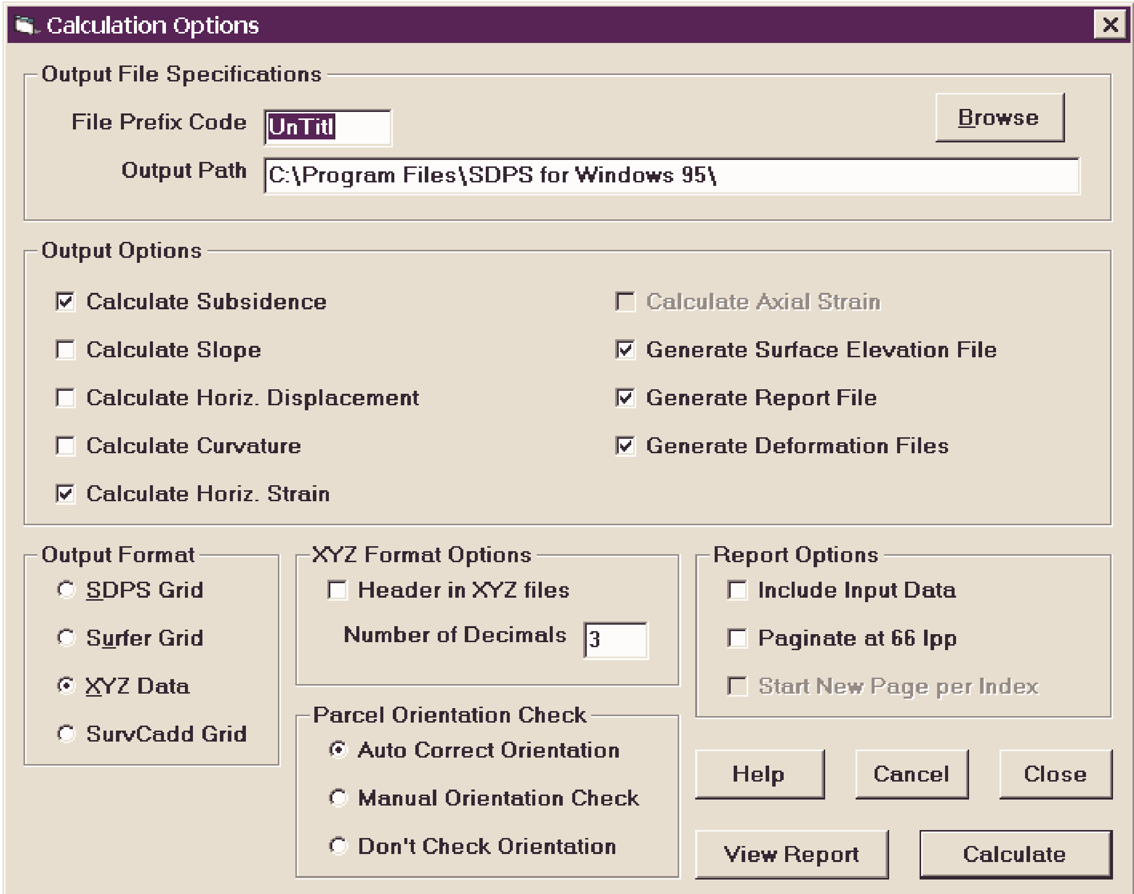


Figure 3.4.4: Output options form

Example 4 Instructions (continued)

7. Click on the **View** button to view the mine plan.
8. Close the viewing window.
9. Click on the **Close** button to exit the input form.
10. Select the **Edit - Prediction Points** option (Figure 3.4.3).
11. Enter the following parameters:
    - minimum easting = -700 ft
    - maximum easting = +700 ft
    - cell size in the x-direction= 50 ft
    - minimum northing = 0 ft
    - maximum northing = 0 ft
    - cell size in the y-direction = 0 ft
    - average elevation = 500 ft
12. Select the View-All button to view the mine plan and points.
13. Close the viewing window.
14. Select the Close button to accept the data.
15. Select the **Calculate - Calculate Deformation** menu item (Figure 3.4.4).
16. Enter **EX2** for the file prefix code and check the options shown in Figure 3.4.4. Click on **OK** to accept the data.
17. Leave the remaining options at their default values.
18. Click on the "*Calculate*" command button.
19. The model will be solved. Close the solution module monitor form.
20. Select the **Graph** option.
21. In the graph module, select the **2-D** option (Figure 3.4.5).
22. Select the appropriate cross-section (X or Y).

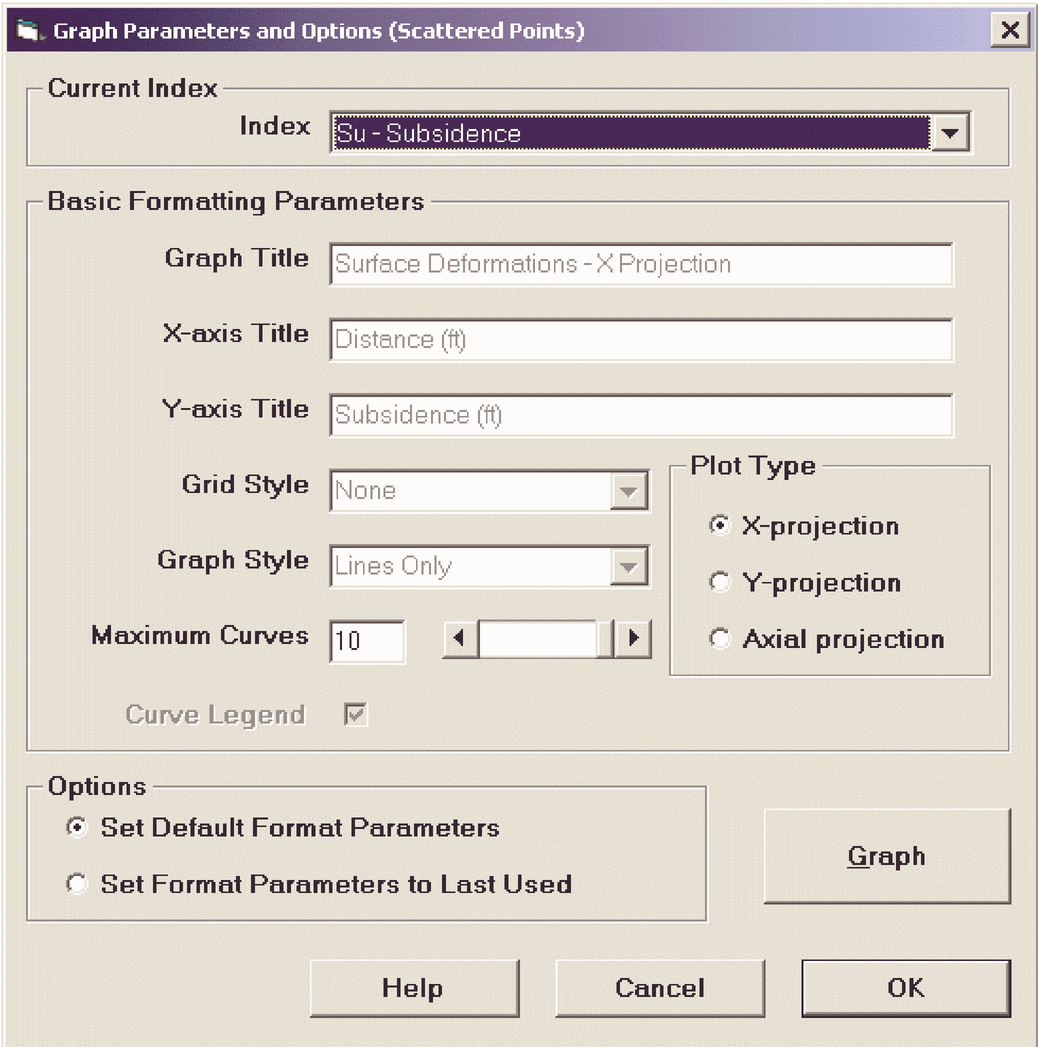


Figure 3.4.5: Graph module, 2D graph options

23. Select the index to view and click on the **Graph** button. A 2-D graph of the selected deformation index will be plotted on the screen.
24. If the option **Set default format parameters** is enabled, then all graph options will be locked. By selecting the **Set format parameters to last used** option, the user can modify current graph settings.

Further Practice:

After completing this original exercise the user may experiment by changing the values one at a time to compare the changes in the curves.

Note for the Novice:

It is a good idea to sketch the mineplan and surface points on a piece of graph paper before using this program.

3.5 Example #5: Calculations Using the Influence Function Program - Adjusting the Panel Boundaries

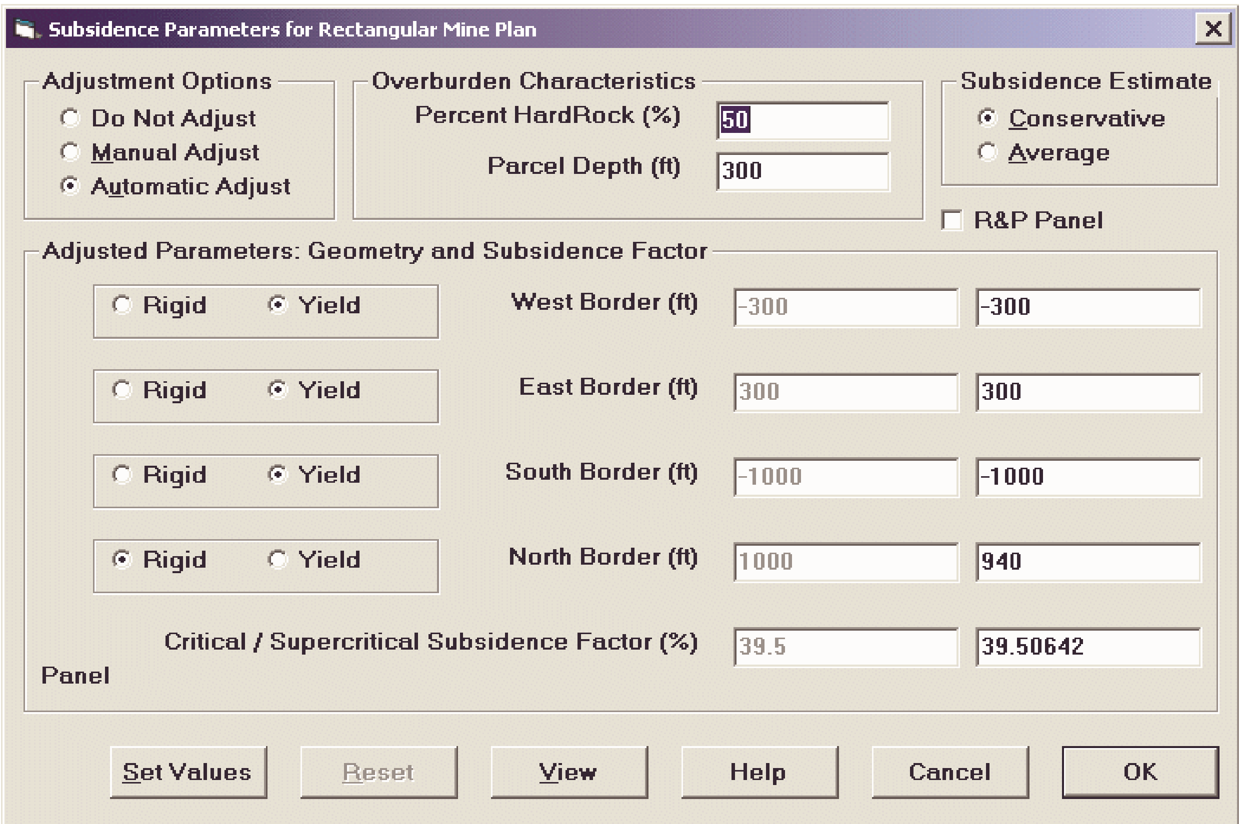


Figure 3.5.1: Subsidence parameters

Example 5 Instructions

1. Execute the Influence Function module.
2. Repeat steps 2 - 5 of example #4.
3. Enter the following parameters:
   - parcel number = 1.01 (automatic)
   - west border = -300 ft
   - east border = +300 ft
   - south border = -1000 ft
   - north border = +1000 ft
   - seam elevation = 0 ft
   - extraction thickness = 6 ft
   - supercrit. subs. factor = 40 %
   - parcel status = active panel
   - adjustments = auto adjust
4. Click on the **Subs. Parm** button (Figure 3.5.1).
5. The form shown in Figure 3.5.1 allows the user to “adjust” panel boundaries, depending on the boundary conditions of each panel. Also, the supercritical subsidence factor may be adjusted.
6. There are three **Adjustment Options.**
7. Selecting **Do not adjust** will disable any adjustments to the geometry of the panel or the supercritical subsidence factor. The original values set in the form as the one shown in Figure 3.4.2 will be used

for the calculations.

8. Selecting **Manual adjust,** the program allows the user to enter specific (measured or other) values in the fields to the right of the original panel coordinates and the original supercritical subsidence factor. The manually adjusted values will be used in the calculations.
9. Selecting **Automatic adjust,** the program automatically calculates the necessary adjustments based on the input in this form (Figure 3.5.1). Such input includes the type of the subsidence estimate, the percent hardrock, the panel depth, etc. The automatically adjusted values will be used in the calculations.
10. In case the user wishes to start from the automatically calculated adjustments and update them to reflect current mining conditions, then **Automatic adjustment** should be selected in this form to calculate the default values and then **Manual adjustment** should be selected to **disable** any further changes to these values.

Notes:

- Under **yield**ing boundary conditions, the boundary is not adjusted.
- The original (geometric) boundaries are kept and displayed when viewing the panel.
- Adjustments are not allowed for pillars.
- Adjustments are not available in polygonal mine plans.

Further Practice:

After completing this original exercise the user may experiment by changing the values one at a time to compare the changes in the curves.

3.6 Example #6: Calculations Using the Influence Function Program - Deformations Around a Panel Edge

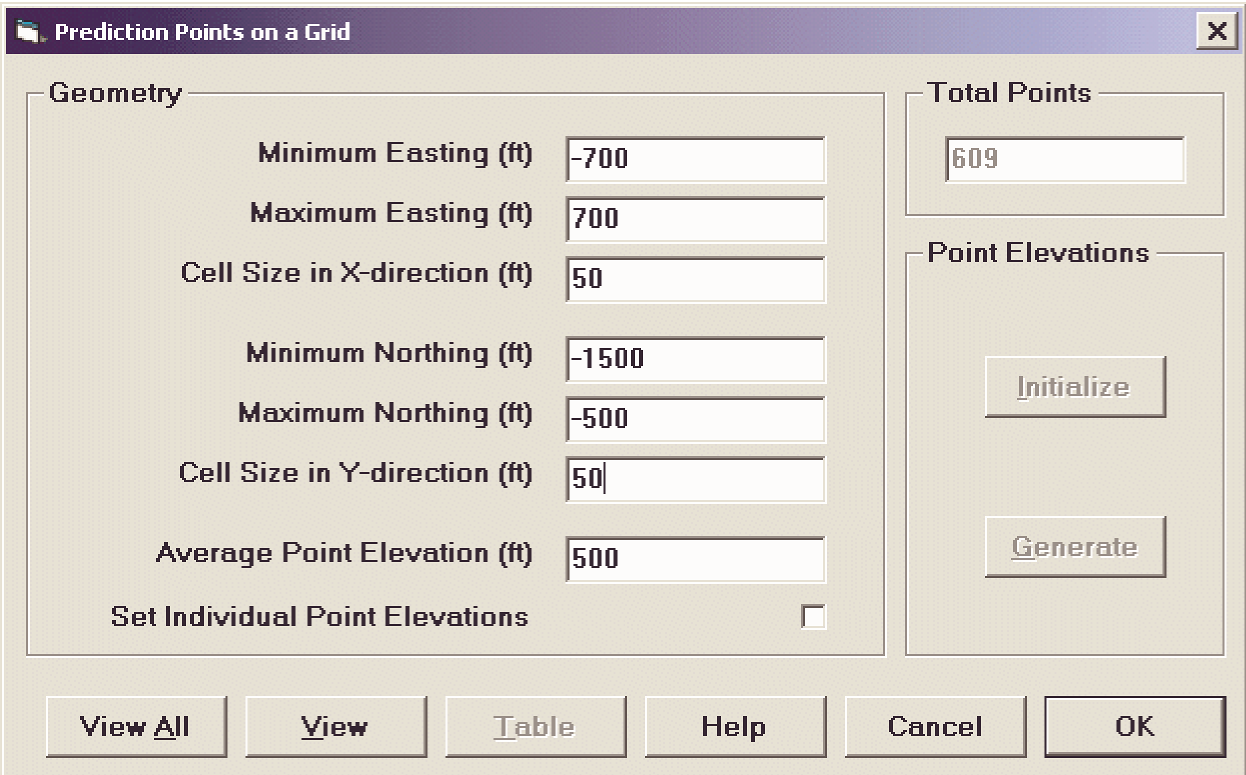


Figure 3.6.1: Grid point input form

Instructions

1. Execute the Influence Function module.
2. Repeat steps 2 - 9 of example #4.
3. Select the **Edit - Prediction Points** option (Figure 3.6.1).
4. Enter the following parameters:
   - minimum easting = -700 ft
   - maximum easting = +700 ft
   - cell size in the x-direction = 50ft
   - minimum northing = -1500 ft
   - maximum northing = 50 ft
   - cell size in the y-direction = 50ft
   - average elevation = 500 ft
5. Select the View All button to view the mine plan and prediction points
6. Close the viewing window.
7. Select the Close button to accept the data.
8. Select the **Calculate - Output Options** menu item.
9. Enter **EX4** for the file prefix code and check the options shown in Figure 3.6.2. Click on **OK** to accept the data.
10. Select the **File - Save Project** option
11. Save the project.
12. Select the **Calculate - Calculate Deformations** option
13. The model will be solved. Close the solution module monitor form.
14. Select the **Graph** option.
15. In the graph module, select **2-D** option.

16. Select the index to view and click on the **Graph** button. You may select a certain section along the X or Y axis to view. A 2D graph of the selected deformation index will be plotted on the screen (Figure 3.6.2). Clicking on the +plane -plane buttons plots of the previous or following sections may be overlaid on the current graph.
17. Close the plot window.
18. Select the 3-D option.
19. Select the index to view and click on the **Graph** button. A 3D graph of the selected deformation index will be plotted on the screen.

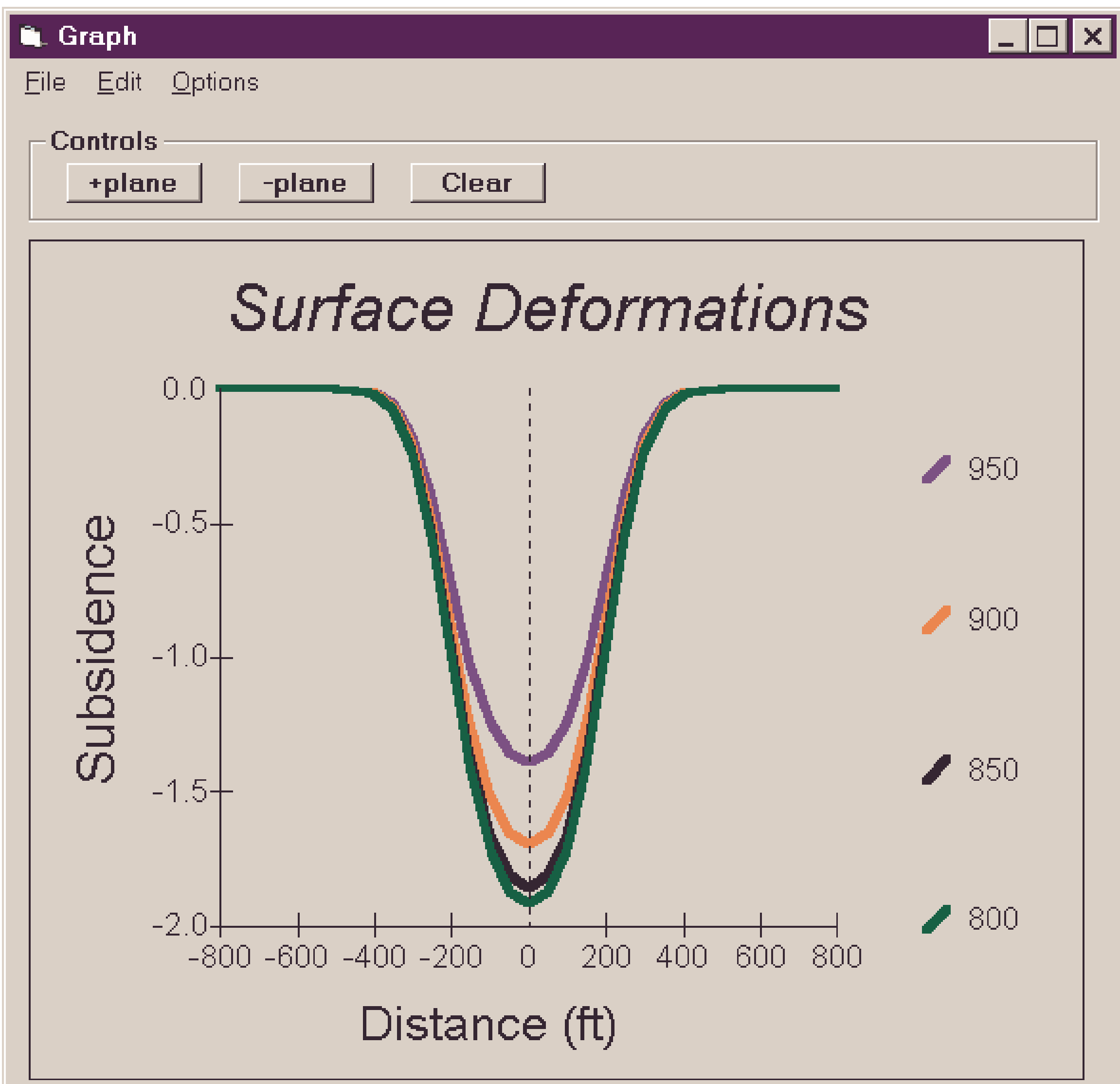


Figure 3.6.2: Transverse subsidence profile

3.7 Example #7: Calculations Using the Influence Function Program - Deformations over Two Longwall Panels

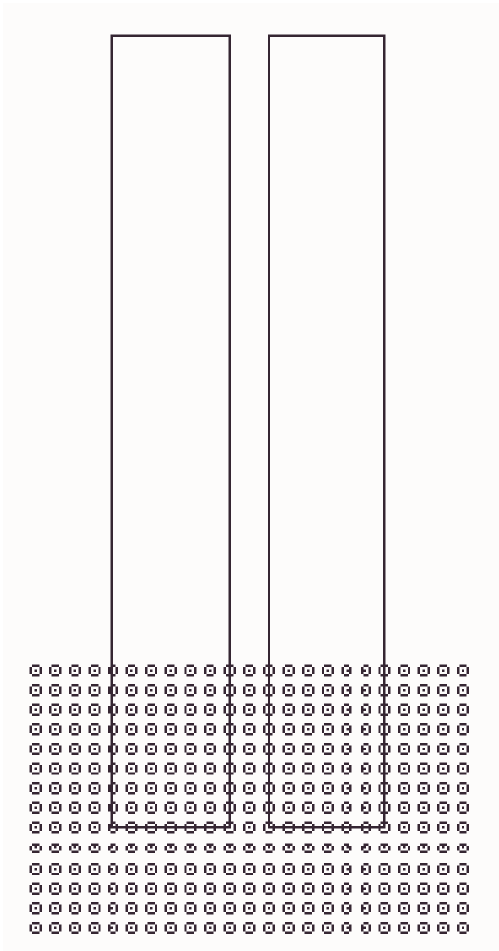


Figure 3.7.1: Mine plan and prediction points

Instructions

1. Execute the Influence Function module.
2. Select the **Edit - Project Description** option.
3. Enter the following parameters:
4. rectangular mine plan
   - grid points
   - angle of Influence = 2.31
   - strain coefficient = 0.35
   - percent hardrock = 50%
5. Click on the **Close** button to exit the input form.
6. Select the **Edit - MinePlan** option and enter the coordinates for the first panel (dimensions = 600 x 4000 ft, elevation = 0 ft, extraction thickness = 6 ft)
   - parcel number = 1.01 (automatic)
   - west border = -300 ft
   - east border = +300 ft
   - south border = -2000 ft
   - north border = +2000 ft
   - seam elevation = 0 ft

- extraction thickness = 6 ft
- supercrit. subs. factor = 39.5 % (automatic)
- parcel status = active panel
- adjustments = do not adjust

7. Click on **Append** in the **Insert Mode** frame. This changes the **Ins Parcel** button to **App Parcel** (if not already changed). Click on the **App Parcel** button (Append mode is enabled if the Append Mode button is selected).
8. Enter the coordinates for the second panel (dimensions 600 x 4000 ft) at a horizontal offset of 200 ft:
   - parcel number = 2.02 (automatic)
   - west border = 500 ft
   - east border = 1100 ft
   - south border = -2000 ft
   - north border = +2000 ft
   - seam elevation = 0 ft
   - extraction thickness = 6 ft
   - supercrit. subs. factor = 39.5 % (automatic)
   - parcel status = active panel
   - adjustments = do not adjust
9. Click on the **Close** button to exit the input form.
10. Select the **Edit - Prediction Points** option.
11. Enter the coordinates for the grid points (to cover the south panel edge of both panels) as follows:
    - minimum easting = -700 ft
    - maximum easting = +1500 ft
    - cell size in the x-direction = 100 ft
    - minimum northing = -2500 ft
    - maximum northing = -1200 ft
    - cell size in the y-direction = 100 ft
    - average elevation = 500 ft
12. Select the **View-All** button to view the mine plan and points (Figure 3.7.1).
13. Close the viewing window.
14. Click on the **Close** button to accept the data.
15. Select the **Calculate - Output Options** menu item.
16. Enter **EX5** for the file prefix code and check the options shown in Figure 3.4.4. Select OK to accept the data.
17. Select the **File - Save Project** option.
18. Save the project.
19. Select the **Calculate - Calculate Deformations** option.
20. The model will be solved. Close the solution module monitor form.
21. Select the **Graph** option.
22. In the graph module, select the **3-D** option.
23. Select the index to view and click on the **Graph** button. A 3D graph of the selected deformation index will be plotted on the screen (Figure 3.7.2).

Further Practice:

After completing this original exercise the user may experiment by changing the values one at a time to compare the changes in the curves.

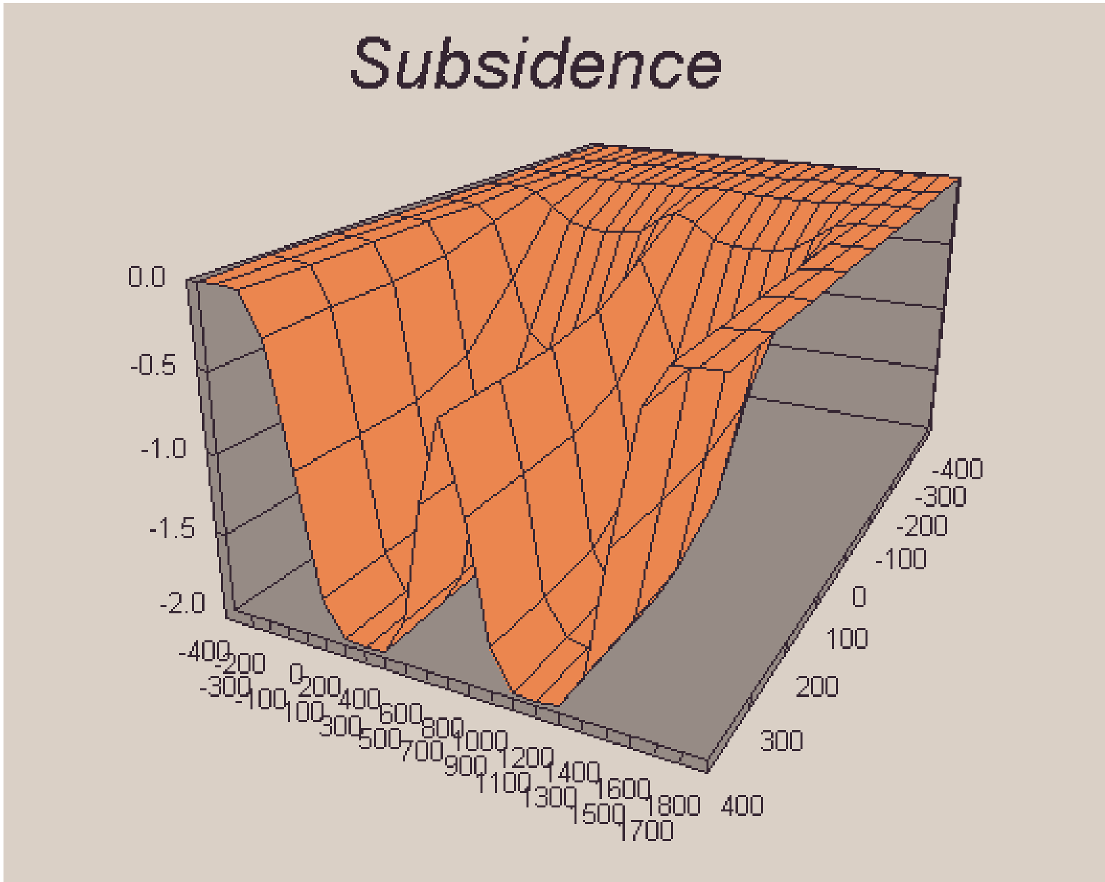


Figure 3.7.2: 3-D image of subsidence over the longwall panels

3.8 Example #8: Calculations Using the Influence Function Program - Deformations over a Room-and-Pillar Section with a Remnant Stable Pillar

Table 3.8.1: Input parameters for example #8

Overburden depth	600 ft	Edge effect	None
Extraction ratio	90 %	Tangent of influence angle	2.31
Extraction thickness	6 ft	Strain coefficient	0.35
Percent hardrock	50 %		

1. Execute the Influence Function module.
2. Select the **Edit - Project Description** option.
3. Enter the following parameters:
   - rectangular mine plan
   - points on a grid
   - angle of influence = 2.31
   - strain coefficient = 0.35
   - percent hardrock = 50%
4. Click on the **OK** button to exit the input form.
5. Select the **Edit - MinePlan** option.
6. Enter the coordinates for the first panel:
   - dimensions = 600 x 400 ft
   - elevation = 0 ft
   - supercrit.subs fact = 34% (*)
   - extraction thickness = 6 ft
   - adjustment = do not adjust
   - panel type = parcel
7. Click on the **R&P Panel** check box. This indicates that the panel is a room-and-pillar panel and, thus, the supercritical subsidence factor should be automatically calculated accordingly. This option should not be confused with the panel and pillar designation of each parcel. The latter is adjusted in the Parcel Type frame of the form.
8. Click on Append in the Insert Mode frame. This changes the Ins Parcel button to App Parcel (if not already changed). Click on the **App Parcel** button.
9. Enter the coordinates for the second parcel (pillar):
   - dimensions = 150 x 100 ft
   - elevation = 0 ft
   - supercrit.subs fact = 34% (*)
   - extraction thickness = 6 ft
   - adjustment = do not adjust
   - parcel type = pillar

   Note that the user is free to select the exact location of the pillar. This is to further acquaint the user with parametric analysis of the influence of underground workings on the surface.
10. Select the **View** button to view the mine plan (Figure 3.8.1).
11. Close the viewing window.
12. Click on the Close button to exit the input form.
13. Select the **Edit - Prediction Points** option.
14. Enter the following parameters:

- grid cell size = 50 ft
- average elevation = 400 ft

15. Click on the **View-All** button to view the mine plan and points (Figure 3.8.1).
16. Close the viewing window.
17. Click on the Close button to accept the data.
18. Select the **Calculate - Output Options** menu item.
19. Check the appropriate options and select OK to accept the data.
20. Select the **File - Save Project** option.
21. Save the project.
22. Select the **Calculate - Calculate Deformations** option.
23. The model will be solved. Close the solution module monitor form.
24. Select the **Graph** option.
25. In the graph module, select the **2-D** option.
26. Select the index to view and click on the **Graph** button. A 2-D graph of the selected deformation index will be plotted on the screen.

(*) Check subsidence tables

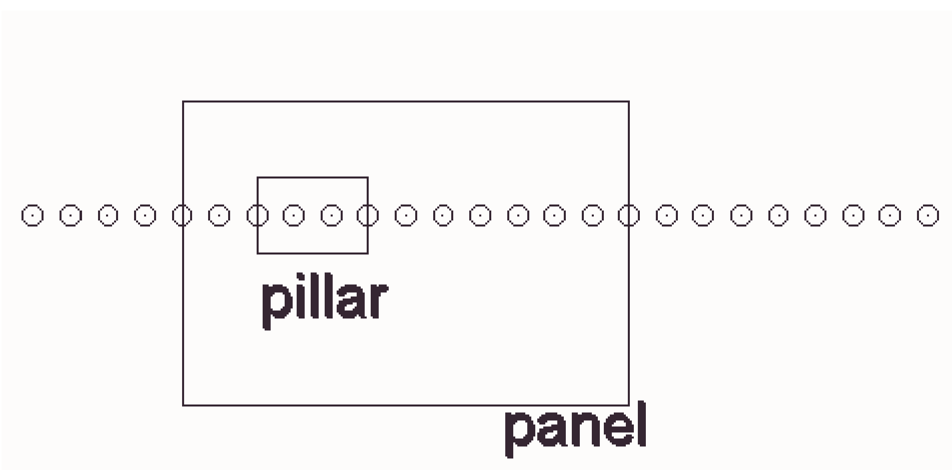


Figure 3.8.1: Mine plan and prediction points

3.9 Example #9: Calculations Using the Influence Function Program - Strains on Pipeline over a Longwall Panel

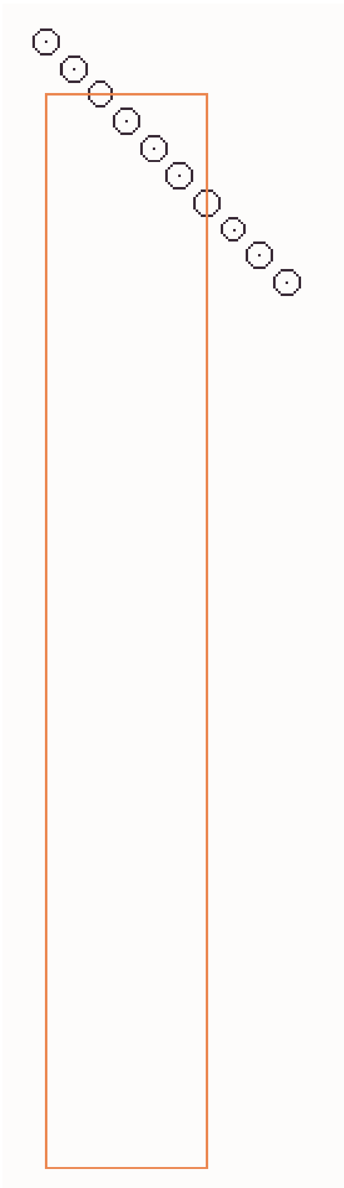


Figure 3.9.1: Mine plan and prediction points

Instructions

1. Execute the Influence Function module.
2. Select the **Edit - Project Description** option.
3. Enter the following parameters:
   - rectangular mine plan
   - scattered points
   - angle of influence = 2.31
   - strain coefficient = 0.35
   - percent hardrock = 50%
4. Click on the **OK** button to exit the input form.
5. Select the **Edit - MinePlan** option.
6. Enter the coordinates for the panel:
   - dimensions = 600 x 4000 ft
   - elevation = 0 ft
   - supercrit.subs fact = 40% (*)
   - extraction thickness = 6 ft
   - adjustment = do not adjust
7. Click on the **View** button to view the mine plan (Figure 3.9.1).
8. Close the viewing window.
9. Click on the **Close** button to exit the input form.
10. Select the **Edit - Prediction Points** option.
11. Enter the parameters for the prediction points as shown in Table 3.9.1. (these are scattered points over the edge of the panel).

Table 3.9.1: Coordinates of prediction points

Easting (x)	northing (y)	elevation (z)
0	4200	610
100	4100	620
200	4000	630
300	3900	640
400	3800	650
500	3700	660
...	...	...

12. Click on the **View-All** button to view the mine plan and points (Figure 3.9.1).
13. Close the viewing window.
14. Click on the **Close** button to accept the data.
15. Select the **Calculate - Output Options** menu item.
16. Check the appropriate options including the options for axial (directional) strain and select OK to accept the data.
17. Select the **File - Save Project** option.
18. Save the project.
19. Select the **Calculate - Calculate Deformations** option.
20. The model will be solved. Close the solution module monitor form.
21. Select the **Graph** option.
22. In the graph module, select the **2-D** option.
23. Select the Ea index (directional strain) to view and click on the **Graph** button. A 2-D graph of the selected deformation index will be plotted on the screen (Figure 3.9.2).

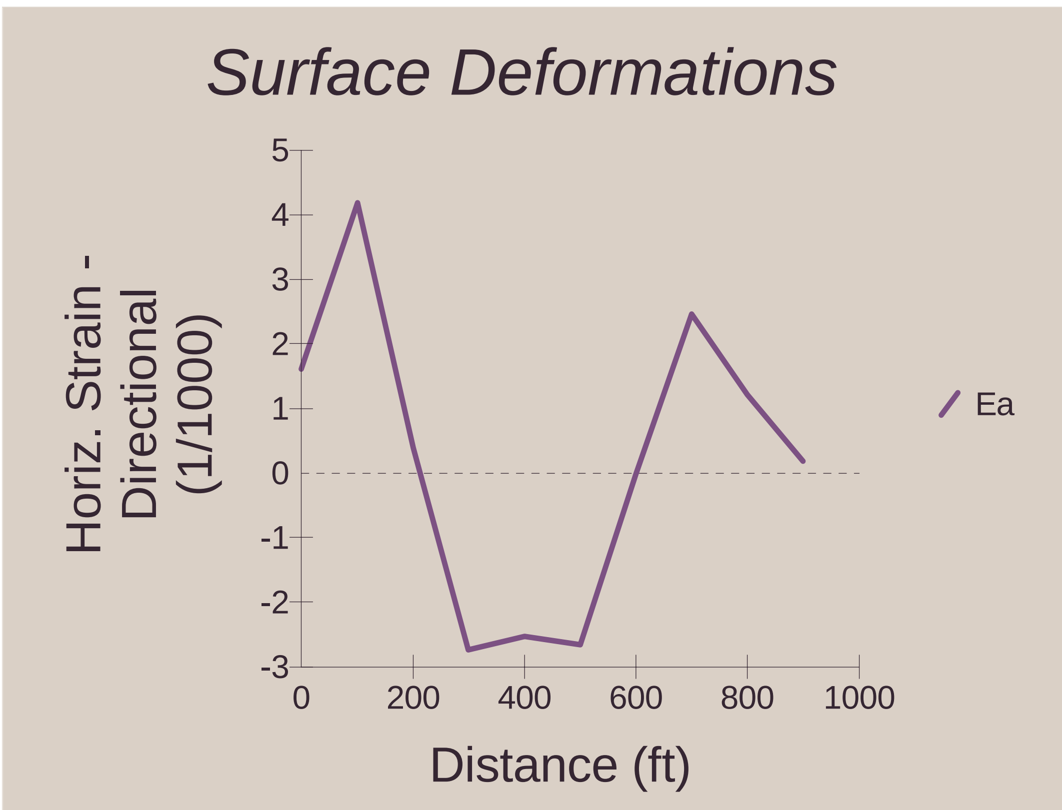


Figure 3.9.2: Directional strain on the pipeline

3.10 Example #10: Calculations Using the Influence Function Program - Deformations due to Multiple Seam Mining

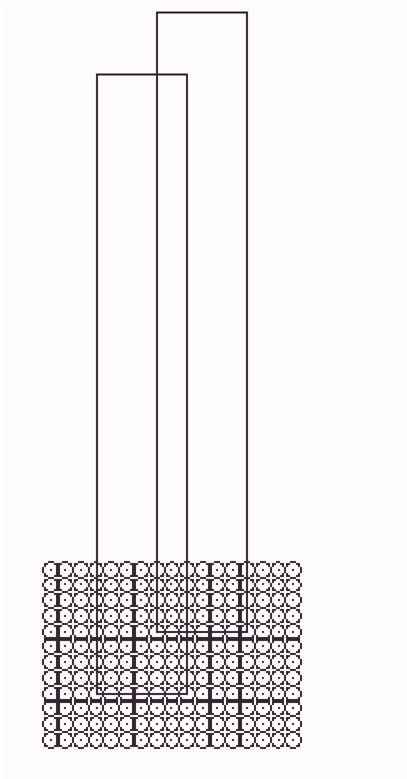


Figure 3.10.1: Mine plan and prediction points

Instructions

1. Execute the Influence Function module.
2. Use default subsidence parameters and influence angle
3. Define two rectangular parcels of 600 x 2000 ft.
4. Position parcels so that they overlap horizontally by 300 ft (Figure 3.10.1).
5. Define the elevation of the bottom parcel as 0 ft.
6. Define the elevation of the top parcel as 200 ft.
7. Define the prediction point datum at +600 ft.
8. Define a grid of points overlapping both parcels with a cell size of 50 ft.
9. Save the project and calculate deformations.
10. Graph deformation indices.

3.11 Example #11: Calculations Using the Influence Function Program - Deformations on a line over a Room & Pillar Section

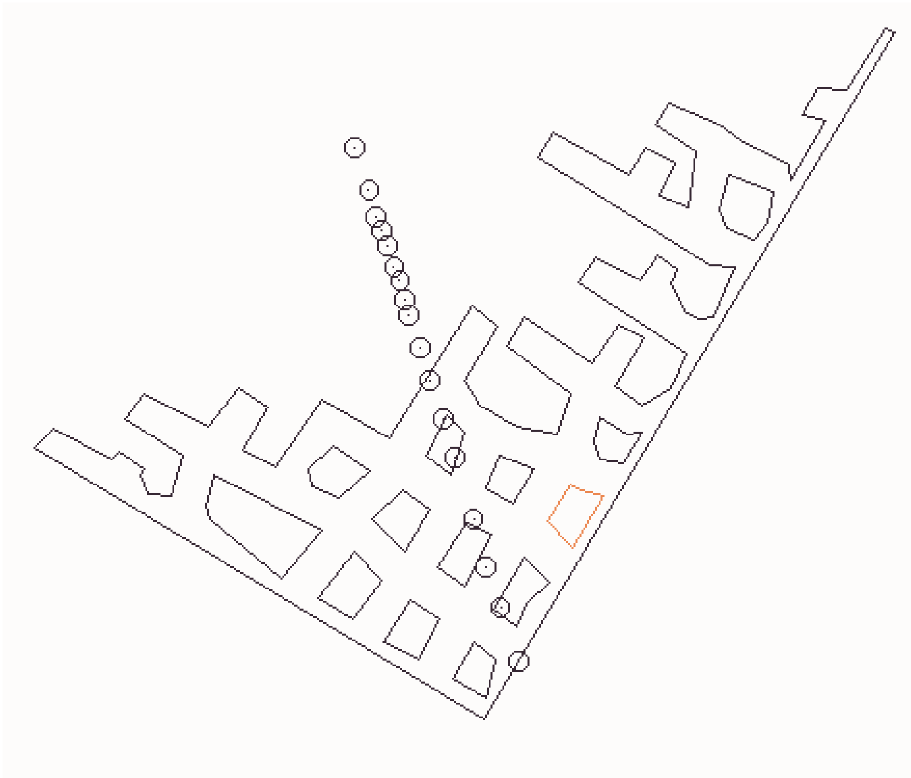


Figure 3.11.1: Mine plan and prediction points

Instructions

(In this example it is assumed that the user is familiar with AutoCAD functions.)

1. Digitize the mine plan and surface points in AutoCAD. Digitize the pillars and panel boundaries as **polylines**. Place all pillars in layer PILLARS, the panel boundary in layer PANELS and the surface points in layer POINTS. Elevations for all entities may be entered. Also, please note that it is recommended that all polylines are digitized in a counter-clockwise fashion. Export all entities in DXF format. Exit AutoCAD.
2. Execute the Influence Function module.
3. Use default subsidence parameters and influence angle.
4. Select the **File - Import SDPS Components** option. Import the mine plan and prediction points in two steps (Figure 3.11.2). Ensure that default layer values for pillars, panels and points are PILLARS, PANELS and POINTS respectively.
5. Select the **Edit - Mine Plan** option and View the mine plan and prediction points (Figure 3.11.1).
6. Select the **Calculate - Output Options** menu item.
7. Check the appropriate options and click on **OK** to accept the data.
8. Select the **File - Save Project** op-

tion.

9. Save the project.
10. Select the **Calculate - Calculate Deformations** option.
11. Allow the program to check the model for clockwise parcels. The model will be solved. Close the solution module monitor form.
12. Select the **Graph** option and view the graphs.

Optionally, the user can import the panels and points **directly** from the AutoCAD DWG file. For this option to work, AutoCAD 2000 or higher should be installed on the same computer as SDPS. To accomplish this, follow these steps:

1. Select the **File - Import SDPS components** option. Select the “AutoCAD DWG” tab and click on “Import from AutoCAD”. Specify the name for the DWG file and select the layer names for panels, pillars and points.
2. When the mine plan and prediction points have been imported go to step 5 above.

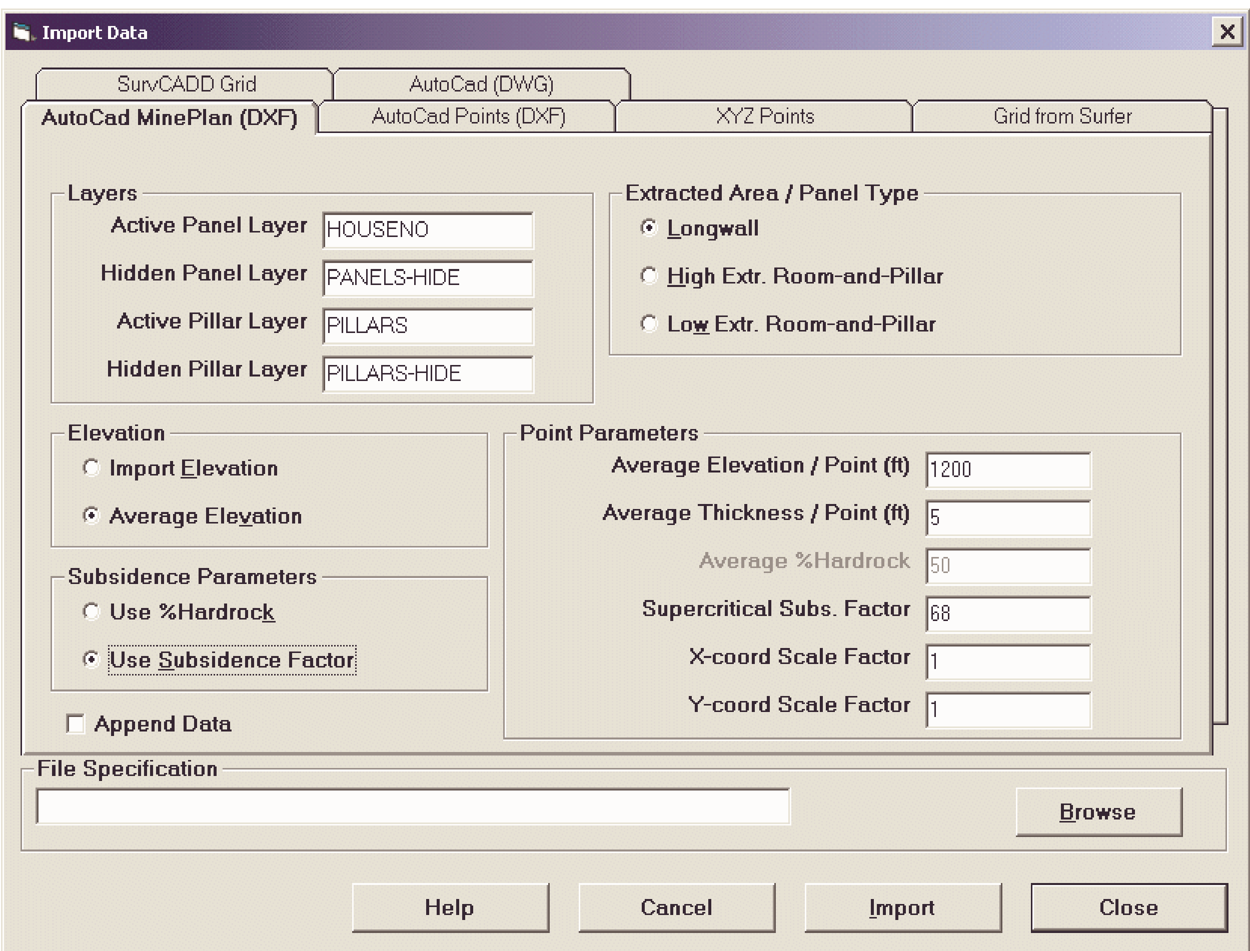


Figure 3.11.2: Import form

3.12 Example #12: Calculations Using the Influence Function Program - Deformations over a Room & Pillar Section Using Data from AutoCAD / SurvCADD

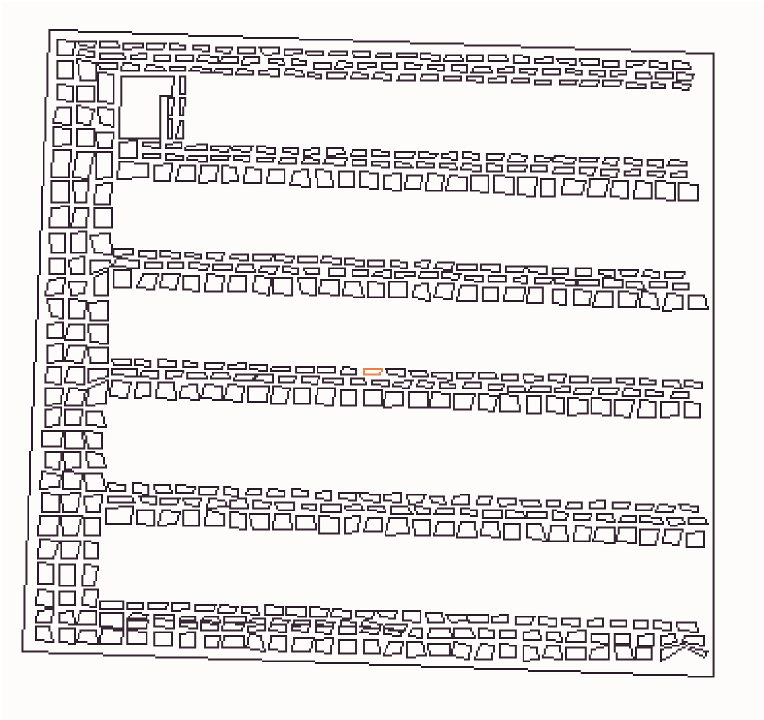


Figure 3.12.1: Mine Plan

Instructions

(In this example it is assumed that the user is familiar with AutoCAD and SurvCADD functions.)

1. Digitize the mine plan in AutoCAD. Digitize the pillars and panel boundaries as **polylines**. Place all pillars in layer PILLARS, the panel boundaries in layer PANELS and the surface points in layer POINTS. Elevations for all entities may be entered. Also, please note that it is recommended that all polylines are digitized in a counter-clockwise fashion. Export all entities in DXF format.
2. Load the surface contour lines (surface topography) in AutoCAD.
3. Create a 3D grid in SurvCADD and save to a file (*.GRD).
4. Exit AutoCAD.
5. Execute the Influence Function module.
6. Select the **File - Import SDPS Components** option. Import the mine plan. Ensure that default layer values for pillars and panels are PILLARS and PANELS respectively.
7. Import the prediction points from the SurvCADD grid file. This is an one-step procedure and no parameters are needed (Figure 3.12.2).
8. Select the **Edit - Mine Plan** option and **View** the mine plan (Figure 3.12.1) and prediction points

(Figure 3.12.3). Note that the mineplan shown in Figure 3.12.1. is incomplete in the sense that the bounding line for the pillars is missing.

9. Select the **Edit - Prediction Points** option and click on the **Table** button to see the data in speadsheet format (Figure 3.12.4) and verify that prediction point elevations are imported properly.
10. Select the **Calculate - Output Options** menu item.
11. Check the appropriate options and click on **OK** to accept the data.
12. Select the **File - Save Project** option.
13. Save the project.
14. Select the **Calculate - Calculate Deformations** option.
15. Allow the program to check the model for clockwise parcels. The model will be solved. Close the solution module monitor form.
16. Select the **Graph** option and view the graphs.

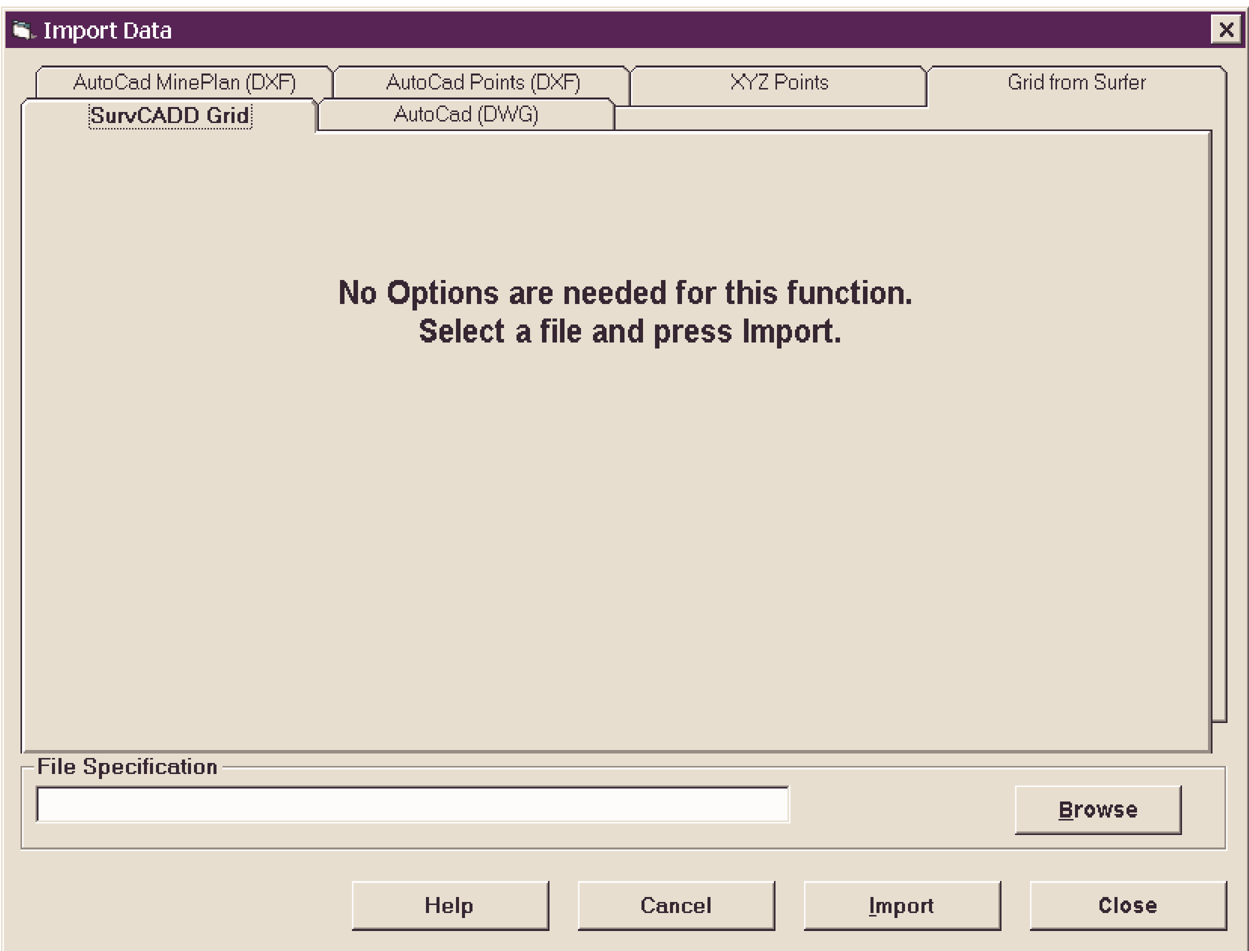


Figure 3.12.2: Importing prediction points from SurvCADD

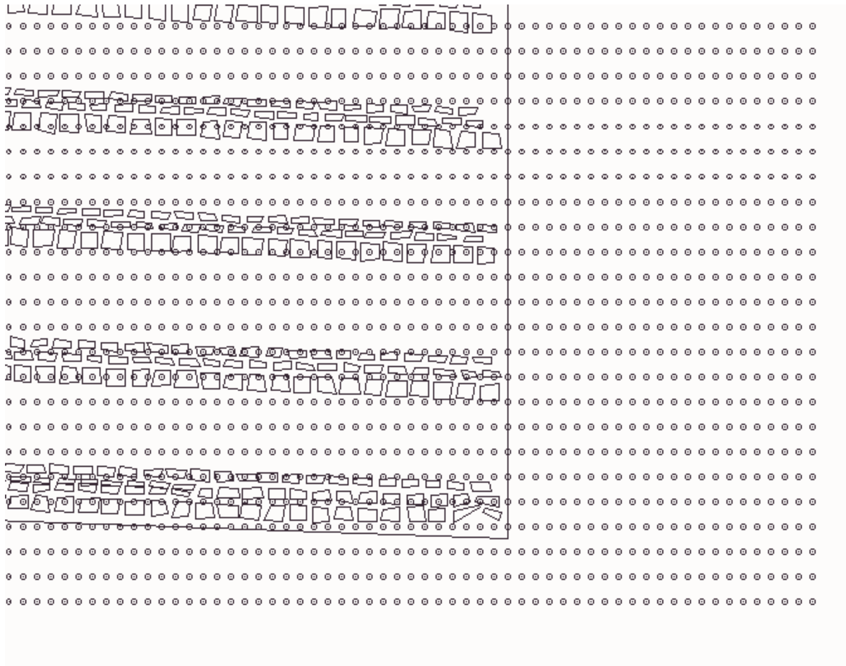


Figure 3.12.3: Partial plan view of mineplan and prediction points

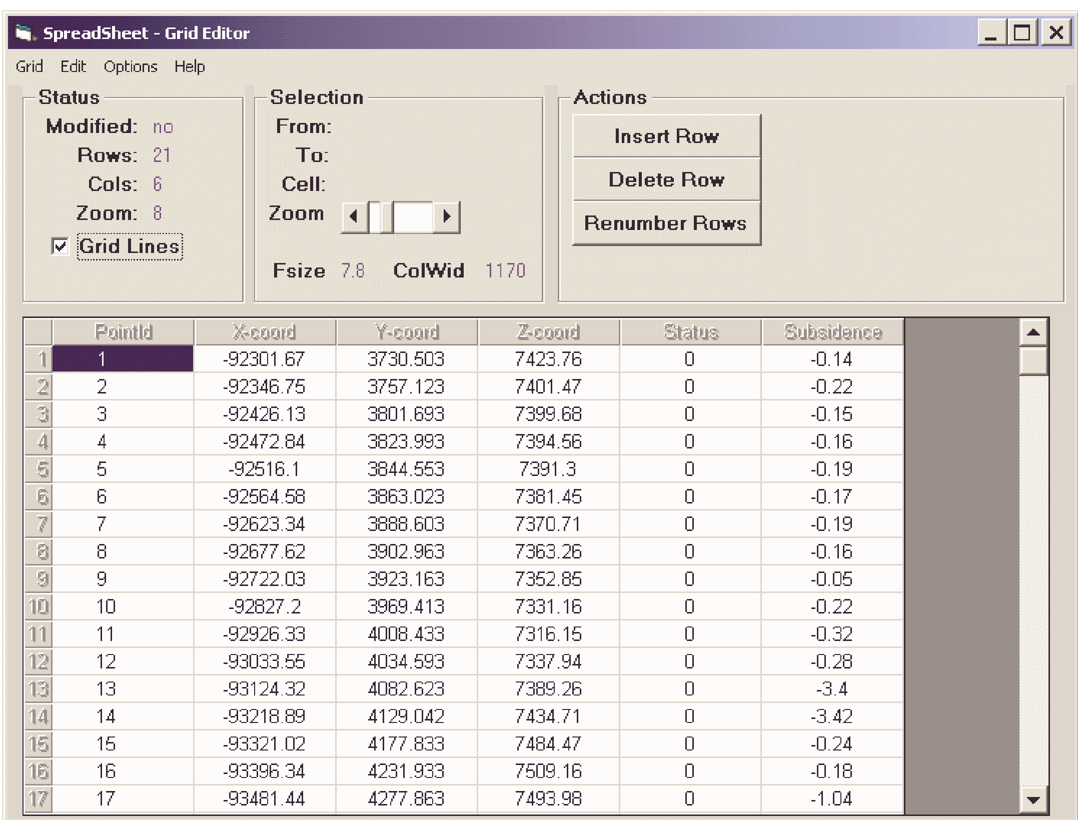


Figure 3.12.4: Editing the surface prediction points in the sheet editor

3.13 Example #13: Calculations Using the Influence Function Program - Develop Site Specific Subsidence Predictions Using Known Field Data

Instructions

1. Execute the Influence Function module.
2. Select the **Edit - Project Description** option.
3. Enter the following parameters:
   - polygonal mine plan
   - scattered points
4. Click on the **OK** button to exit the input form.
5. Select the **Utilities - Options** function.
6. Enable the **Calibration Feature** (if not already enabled).
7. Define the mine plan.
8. Define the prediction points. **Enter the measured subsidence value for every point.**
9. Select the **Calculate - Calibration Options** function (Figure 3.13.1-2).
10. Select the range for the tangent of the influence angle, the range of the subsidence factor, and the range for the edge effect. Note that the edge effect applies to all sides of a polygonal panel.
11. Save the project.
12. Select the **Calculate - Calibrate Influence Function** option.
13. The solution module will invoked and the values of the tangent of the influence angle and of the subsidence factor will be calculated for all cases. The values that minimize the total error between the predicted and measured subsidence values will be suggested as the site specific values.
14. The user has the option to **Graph** the measured and predicted subsidence values and visually inspect the match. Also, the user can print summary and detailed reports for the calibration procedure.

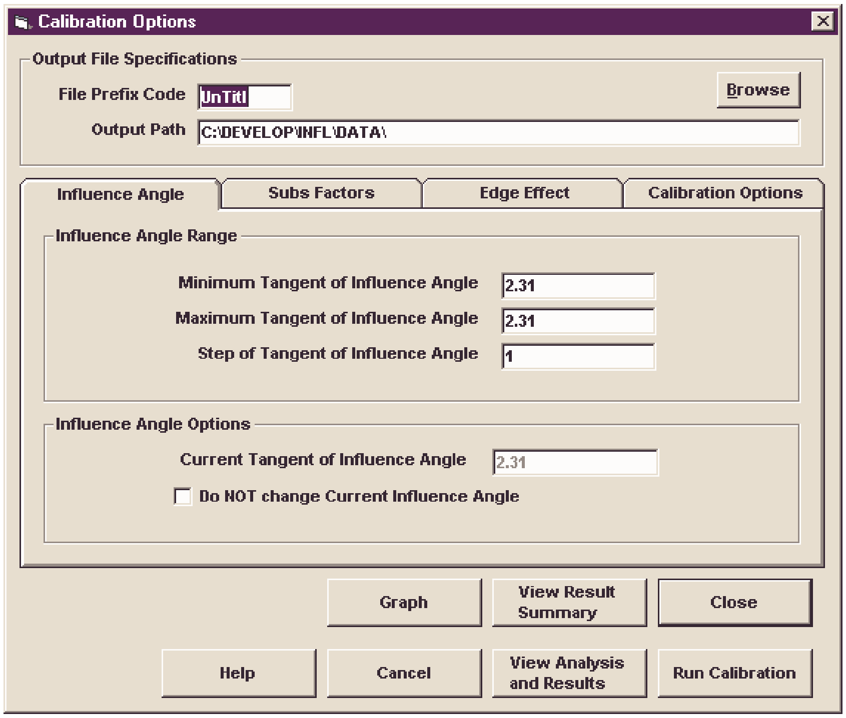


Figure 3.13.1: Calibration options

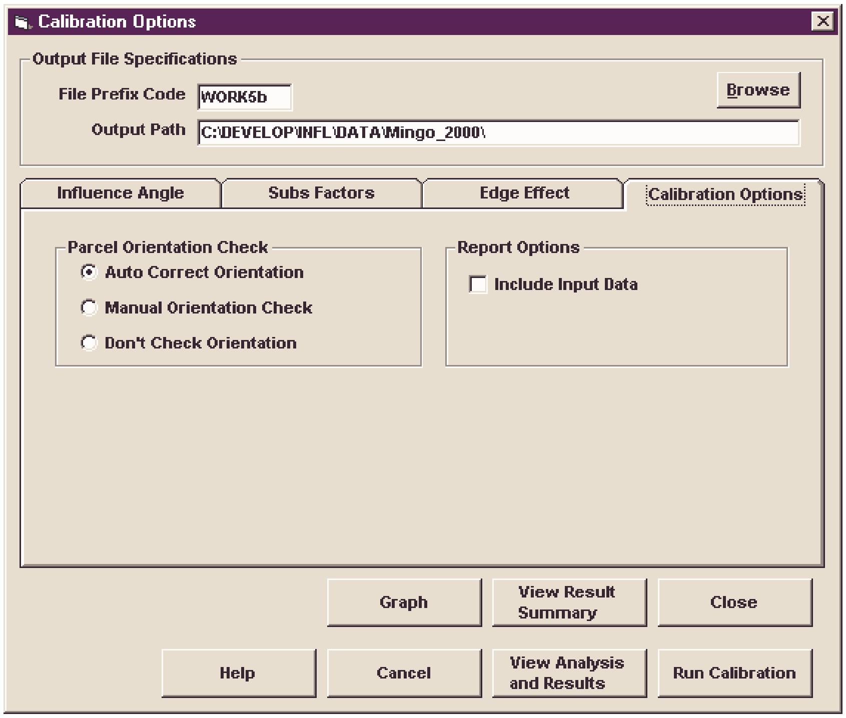


Figure 3.13.2: Calibration options

3.14 Example #14: Site Specific Parameters for a Room-and-Pillar Case Study - Influence Function method

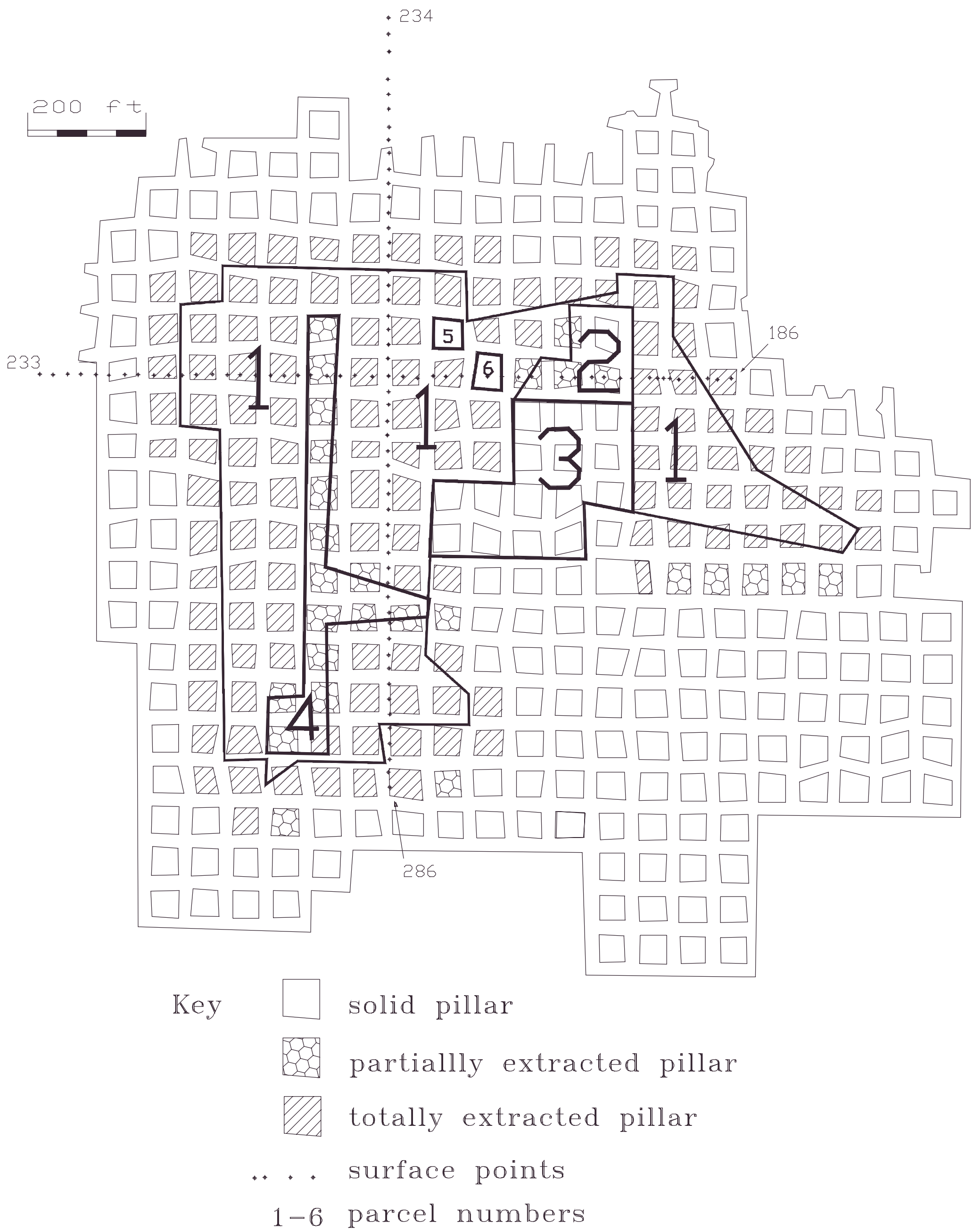


Figure 3.14.1: Mine Plan and Parcel Layout, Example #14

Description

This example represents an actual room-and-pillar case study monitored by Virginia Polytechnic Institute and State University, identified as RUVAVT2. It was selected due to its complicated mining geometry and unique, as well as highly variable, mining and geological parameters. In this particular mine, the amount of hardrock ranged from 40% to 80%, the overburden was extremely shallow (average depth 365 feet), and the extraction method produced a highly irregular excavation geometry, since pillars were often left in place in order to combat ground control problems.

Subsidence predictions for such a case study, using a general method based on average field values, will not yield accurate results. However, the prediction methods can be modified by adjusting the empirical parameters used to calculate subsidence and strain so that the predicted profiles are forced to *fit* the measured profiles (VPI&SU 1987). Thus, the general prediction method can be transformed to a site-specific prediction model for a particular case study. This was accomplished by applying the influence function method and employing a trial and error procedure in order to calculate the values for the tangent of the influence angle and the strain coefficient for the particular case study. The *input parameters* shown in Table 3.14.1 correspond to those that produced the best match between measured and calculated subsidence and strain profiles.

Parameters

The mine plan for this case study is shown in Figure 3.14.1. Before entering the mine plan data into the influence function program, a decision was made with respect to the most appropriate method to represent the mine plan in a digital form. Since the mine plan could be divided into areas of relatively *uniform* extraction, it was decided that it would be much quicker, without loss of accuracy in the predictions, to represent the mine plan as a set of six (6) parcels. Three (1-3) of these represent extracted areas, while the remaining three (4-6) represent pillars or pillar areas. Using this procedure, one can avoid entering the coordinates of each individual pillar into the mine plan. Once the excavated area was identified on the mine map, the outer boundaries of that area were modified by the edge effect before the parcel coordinates were entered into the program. The mine plan points, prediction point data, and the empirical parameters used in this example are summarized in Table 3.14.1.

The empirical parameters for this example were obtained as follows:

- The edge effect was calculated using the conservative line of Figure 3.2.1 for W/h = 1.2. Thus d = 0.2 x 365 = 73ft.
- The default value for the tangent of the influence angle was selected as the initial value. The influence function program was executed and the predicted subsidence values were compared to the measured data. Subsequently, the initial value was modified until a satisfactory match between the measured and predicted subsidence values was obtained.
- The default value for the strain coefficient was selected as the initial value. The influence function program was executed and the predicted strain values were compared to the measured data. Subsequently, the initial value was modified

until a satisfactory match between the measured and predicted strain values was obtained.

- The subsidence factors were calculated as follows:
  - 40%HR, high extraction room-and-pillar => subs.factor = 42%
  - 40%HR, 70% extraction room-and-pillar => subs.factor = 42%*0.7 = 29%
  - 40%HR, 50% extraction room-and-pillar => subs.factor = 42%*0.5 = 21%

Notes:

- The edge effect value was not modified, since a good match was obtained by manipulating the influence angle. In other case studies, manipulation of the edge effect may be necessary.
- The extraction ratios given for each parcel are the average ratios measured for the corresponding parcels.
- The subsidence factors for pillars are negative values and are calculated as a percentage of the supercritical subsidence factor based on the remaining portion of the pillar.

The mine plan and prediction point coordinates are detailed in Tables 3.14.1, 3.14.2 and 3.14.3. Note that all coordinates are given in feet.

The influence function program was setup for polygonal parcels and points on a grid. For simplicity a local coordinate system was selected with the origin in the middle of the panel. Figure 3.14.2 compares the fitted and measured subsidence profiles, while Figure 3.14.3 compares the fitted and measured strain profiles, in the transverse direction. Figures 3.14.4 and 3.14.5 show corresponding comparisons in the longitudinal direction. Figure 3.14.6 presents subsidence contours over the affected area, while Figure 3.14.7 presents a three-dimensional projection of the subsidence trough over that area. Figure 3.14.8 presents the corresponding strain contours.

Notes:

- Subsidence and maximum strain contouring was accomplished using third party contouring packages.

Table 3.14.1: Input parameters for example #14

Excavation Parcel	No. of Data Points	Smax [ft]	Elevation [ft]	Extraction Thickness [ft]	Extraction Ratio [%]	Subsid. Factor [%]
1	32	2.10	2,400	5	85%	42
2	6	1.85	2,400	5	70%	29
3	8	1.05	2,400	5	50%	21
4 *	10	1.85	2,400	5	70%	−13
5 *	4	0	2,400	5	0	−42
6 *	4	0	2,400	5	0	−42

(*) Negative subsidence factors describe the effect of the remnant pillars. In the program, positive subsidence factors are entered and the pillar option is enabled.

Grid Parameters of Prediction Points	Value
Minimum easting [ft]	−900
Maximum easting [ft]	1200
Cell size in X-direction [ft]	50
Minimum northing [ft]	−900
Maximum northing [ft]	400
Cell size in Y-direction [ft]	50
Avg surface elevation [ft]	2765

Empirical Parameters	Value
Tangent of influence angle	4.29
Strain coefficient	0.12
Edge effect, conservative estimate [ft]	73

Table 3.14.2: Mine plan coordinates, example #14

[MINE PLAN DATA]
[Polygonal Mine Plan]
Total Parcels: 6

Parcel No: 1 -> Points: 32 Status: Active Panel

Point No	Easting	Northing	Seam Elevation	Extraction Thickness	Subs. Factor
3.000	806.54	-258.31	2425.00	5.00	42.00
4.000	637.79	-159.98	2415.00	5.00	42.00
5.000	486.75	64.68	2405.00	5.00	42.00
6.000	487.98	163.35	2400.00	5.00	42.00
7.000	392.82	167.22	2400.00	5.00	42.00
8.000	391.41	139.84	2400.00	5.00	42.00
9.000	133.76	89.74	2390.00	5.00	42.00
10.000	130.54	175.49	2390.00	5.00	42.00
11.000	-286.65	183.04	2380.00	5.00	42.00
12.000	-290.27	123.51	2380.00	5.00	42.00
13.000	-360.26	120.56	2380.00	5.00	42.00
14.000	-360.31	-89.85	2380.00	5.00	42.00
15.000	-295.96	-92.80	2380.00	5.00	42.00
16.000	-286.92	-650.15	2390.00	5.00	42.00
17.000	-214.77	-653.62	2390.00	5.00	42.00
18.000	-212.37	-692.75	2390.00	5.00	42.00
19.000	-157.89	-653.75	2395.00	5.00	42.00
20.000	-9.88	-654.90	2400.00	5.00	42.00
21.000	-16.37	-588.94	2400.00	5.00	42.00
22.000	134.34	-591.53	2410.00	5.00	42.00
23.000	133.03	-537.35	2410.00	5.00	42.00
24.000	63.49	-471.10	2410.00	5.00	42.00
25.000	74.61	-178.74	2410.00	5.00	42.00
26.000	212.24	-183.73	2410.00	5.00	42.00
27.000	210.40	-45.24	2400.00	5.00	42.00
28.000	238.25	-2.80	2400.00	5.00	42.00
29.000	260.97	27.45	2400.00	5.00	42.00
30.000	314.29	21.93	2400.00	5.00	42.00
31.000	309.91	115.94	2395.00	5.00	42.00
32.000	419.47	112.37	2400.00	5.00	42.00
33.000	421.44	-229.67	2420.00	5.00	42.00
34.000	778.03	-300.05	2430.00	5.00	42.00

Parcel No: 2 -> Points: 6 Status: Active Panel

Point No	Easting	Northing	Seam Elevation	Extraction Thickness	Subs. Factor
35.000	417.98	-48.65	2405.00	5.00	29.00
36.000	420.86	113.02	2400.00	5.00	29.00
37.000	313.33	115.85	2395.00	5.00	29.00
38.000	313.57	20.58	2400.00	5.00	29.00
39.000	260.22	24.73	2400.00	5.00	29.00
40.000	211.09	-45.26	2400.00	5.00	29.00

Table 3.14.3: Mine plan coordinates, continued, example #14

Parcel No: 3 -> Points: 8 Status: Active Panel

Point No	Easting	Northing	Seam Elevation	Extraction Thickness	Subs. Factor
41.000	419.33	-231.67	2420.00	5.00	21.00
42.000	417.94	-50.02	2405.00	5.00	21.00
43.000	211.77	-45.28	2400.00	5.00	21.00
44.000	213.59	-184.45	2410.00	5.00	21.00
45.000	75.26	-180.13	2410.00	5.00	21.00
46.000	68.56	-304.69	2410.00	5.00	21.00
47.000	337.84	-306.98	2415.00	5.00	21.00
48.000	338.21	-215.15	2415.00	5.00	21.00

Parcel No: 4 -> Points: 10 Status: Active Pillar

Point No	Easting	Northing	Seam Elevation	Extraction Thickness	Subs. Factor
49.000	-89.44	98.35	2390.00	5.00	-13.00
50.000	-141.49	99.72	2390.00	5.00	-13.00
51.000	-148.07	-540.92	2400.00	5.00	-13.00
52.000	-209.83	-544.09	2400.00	5.00	-13.00
53.000	-207.53	-638.73	2390.00	5.00	-13.00
54.000	-105.39	-638.00	2395.00	5.00	-13.00
55.000	-107.91	-421.35	2400.00	5.00	-13.00
56.000	63.19	-404.61	2410.00	5.00	-13.00
57.000	61.87	-376.48	2410.00	5.00	-13.00
58.000	-110.74	-320.53	2400.00	5.00	-13.00

Parcel No: 5 -> Points: 4 Status: Active Pillar

Point No	Easting	Northing	Seam Elevation	Extraction Thickness	Subs. Factor
59.000	120.82	92.82	2390.00	5.00	-42.00
60.000	74.95	94.71	2390.00	5.00	-42.00
61.000	76.40	45.33	2390.00	5.00	-42.00
62.000	126.43	45.38	2390.00	5.00	-42.00

Parcel No: 6 -> Points: 4 Status: Active Pillar

Point No	Easting	Northing	Seam Elevation	Extraction Thickness	Subs. Factor
63.000	189.84	32.75	2395.00	5.00	-42.00
64.000	150.24	38.59	2395.00	5.00	-42.00
65.000	143.12	-23.59	2395.00	5.00	-42.00
66.000	191.66	-28.30	2395.00	5.00	-42.00

Table 3.14.4: Prediction points coordinates, example #14

Scattered Points
Transverse Profile

Point No	Easting	Northing	Elevation
186	575.02	-0.15	2834.26
187	549.91	-0.26	2836.55
188	525.11	-0.21	2835.44
189	500.01	-0.16	2832.53
190	475.31	-0.18	2829.46
191	450.27	-0.12	2826.09
192	424.20	-0.11	2822.94
193	400.25	-0.02	2820.42
194	375.08	-0.15	2819.67
195	350.40	-0.19	2820.14
196	325.24	1.13	2820.49
197	300.30	-0.22	2820.76
198	275.31	-0.05	2821.77
199	250.31	-0.20	2823.22
200	225.21	-0.26	2824.45
201	200.21	-0.15	2824.18
202	175.25	-0.28	2822.27
203	150.21	-0.34	2819.70
204	125.37	-0.22	2815.94
205	100.15	-0.24	2811.96
206	75.11	-0.17	2809.03
207	50.10	-0.25	2805.59
208	25.11	-0.27	2803.34
209	-0.03	-0.13	2799.96
210	-24.95	-0.15	2797.76
211	-49.77	-0.29	2791.73
212	-75.64	0.39	2787.67
213	-99.67	0.02	2783.61
214	-125.33	-0.31	2778.05
215	-149.89	-0.08	2774.32
216	-174.94	-0.18	2770.75
217	-199.88	-0.16	2768.04
218	-225.08	-0.17	2765.08
219	-249.76	-0.07	2761.25
220	-274.85	-0.15	2758.27
221	-299.87	0.05	2754.71
222	-324.94	-0.21	2750.46
223	-349.87	-0.07	2746.48
224	-374.80	-0.04	2741.49
225	-399.93	-0.18	2735.62
226	-424.20	-0.13	2733.80
227	-449.97	0.11	2726.78
228	-475.39	-0.13	2721.38
229	-500.35	-0.02	2716.60
230	-523.87	-0.89	2711.98
231	-550.09	-5.46	2706.58
232	-575.19	-6.01	2703.62
233	-599.09	-5.77	2701.52

Scattered Points
Longitudinal Profile

Point No	Easting	Northing	Elevation
234	-0.15	600.43	2703.73
235	-0.33	574.67	2709.03
236	0.10	550.01	2713.94
237	1.14	524.97	2715.99
238	0.19	499.75	2720.67
239	0.15	474.86	2724.51
240	0.15	449.95	2728.80
241	-0.61	424.80	2733.62
242	0.31	399.67	2736.40
243	-0.02	374.42	2738.85
244	0.16	349.50	2741.92
245	-0.03	323.58	2746.09
246	-0.08	299.79	2747.68
247	0.01	275.07	2750.19
248	0.40	249.04	2754.17
249	0.15	224.26	2758.77
250	0.27	199.84	2767.18
251	0.03	175.10	2770.00
252	0.28	149.94	2770.86
253	0.30	124.84	2770.91
254	0.29	99.98	2775.58
255	0.25	75.03	2784.12
256	-0.04	49.86	2789.90
257	0.36	26.41	2798.08
258	-0.04	-0.13	2799.96
259	0.20	-25.24	2802.69
260	0.21	-45.09	2801.82
261	0.07	-75.01	2802.35
262	0.16	-99.65	2800.11
263	-0.50	-124.95	2798.59
264	0.22	-149.87	2795.08
265	0.32	-175.09	2790.60
266	0.25	-199.94	2784.78
267	0.27	-224.97	2779.95
268	0.36	-250.05	2774.73
269	0.22	-275.50	2769.83
270	0.56	-300.06	2765.09
271	-0.85	-324.72	2758.94
272	0.34	-350.12	2754.21
273	0.49	-375.02	2758.21
274	0.55	-399.95	2764.05
275	0.25	-425.13	2771.88
276	0.66	-450.22	2776.86
277	0.49	-475.36	2780.58
278	0.33	-500.18	2787.56
279	-0.06	-525.02	2794.43
280	0.46	-550.19	2797.32
281	0.57	-575.08	2792.31
282	0.43	-599.91	2784.80
283	0.45	-625.22	2777.68
284	0.51	-650.37	2769.98
285	0.48	-675.02	2761.06
286	0.57	-700.41	2749.46

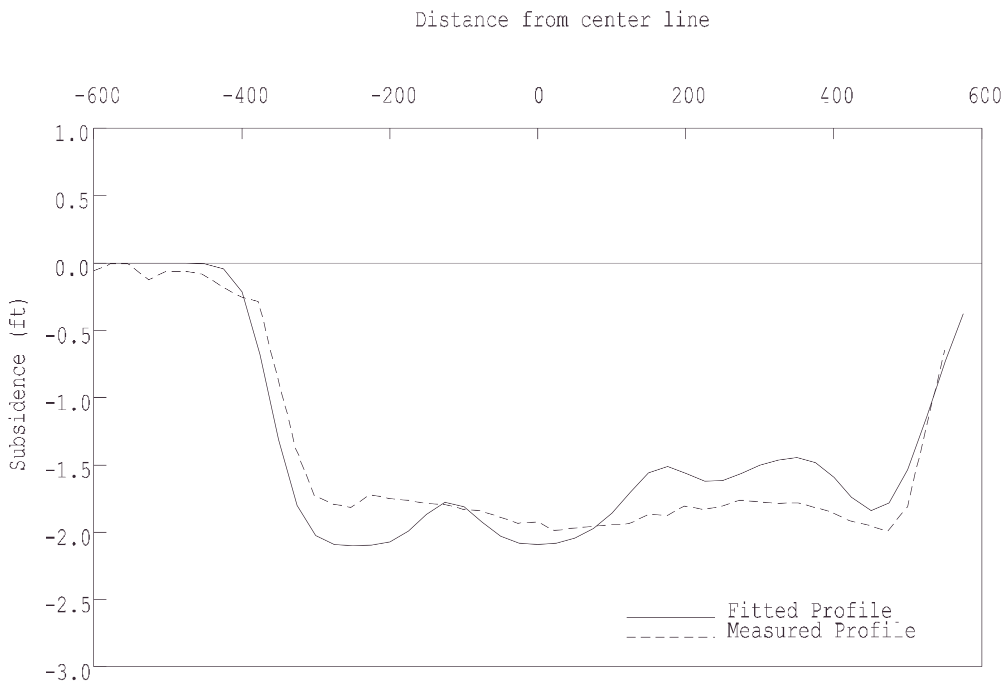


Figure 3.14.2: Comparison of fitted and measured transverse subsidence profiles, example #14 (points 233-186)

Figure 3.14.3: Comparison of fitted and measured transverse strain profiles, example #14 (points 233-186)

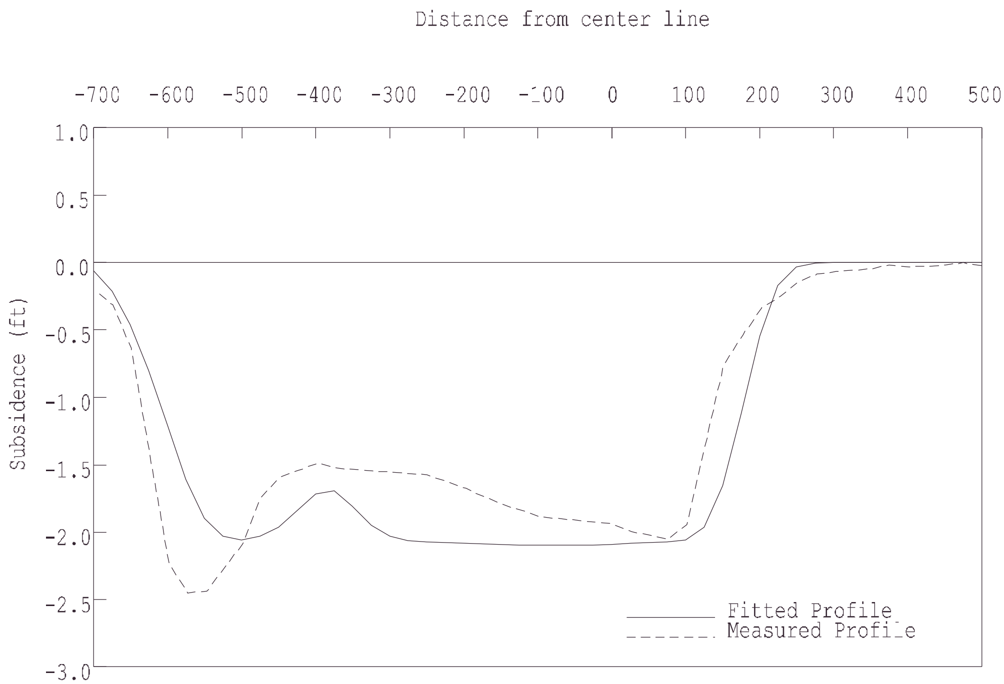


Figure 3.14.4: Comparison of fitted and measured longitudinal subsidence profiles, example #14 (points 286-234)

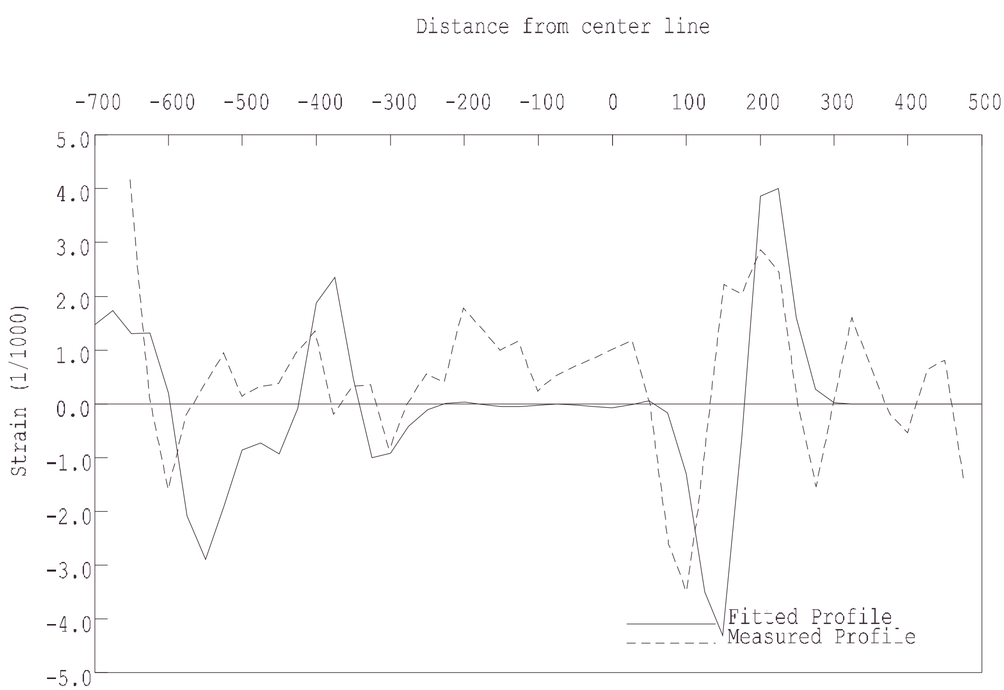


Figure 3.14.5: Comparison of fitted and measured longitudinal strain profiles, example #14 (points 286-234)

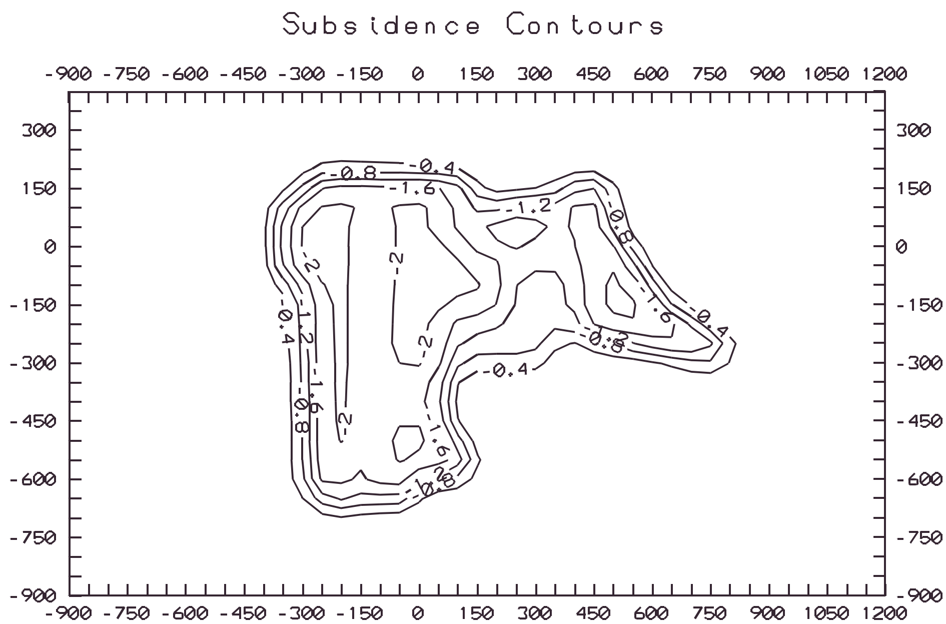


Figure 3.14.6: Subsidence contours, example #14

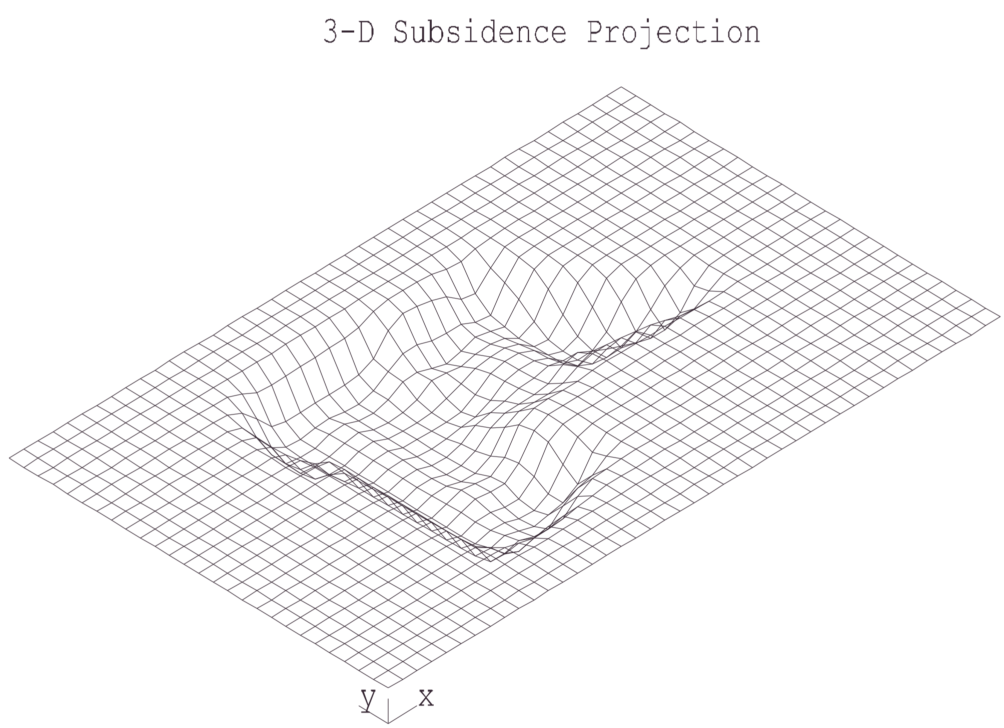


Figure 3.14.7: Subsidence orthographic projection, example #14

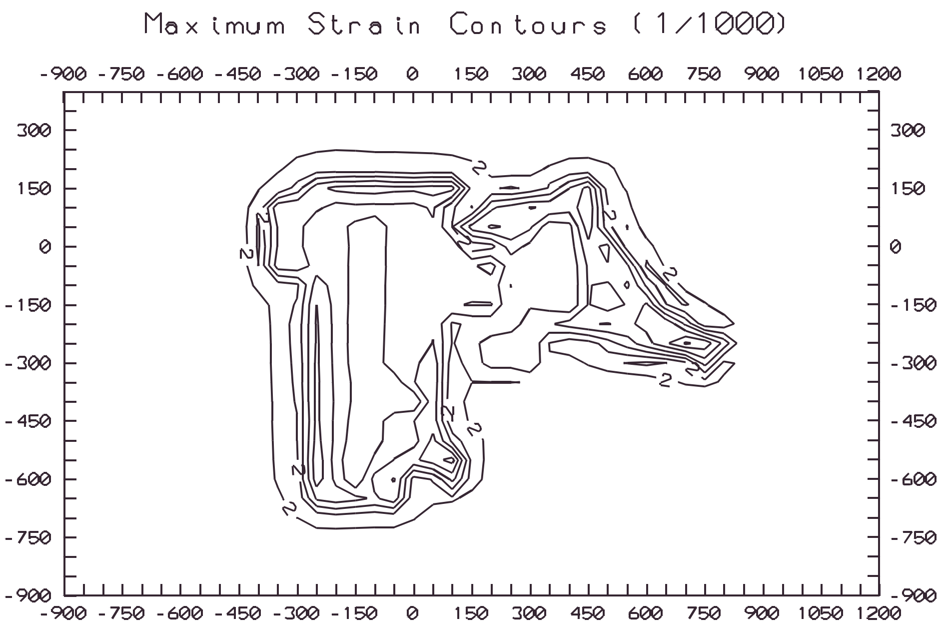


Figure 3.14.8: Maximum strain contours, example #14

Chapter 4: Pillar Stability Analysis Calculations

Pillar design should take into consideration the function of a pillar or a set of pillar during the lifetime of a mining section. Since the original pillar design formulations were proposed several decades ago, other formulations have been developed to address pillar stability. The SDPS suite of programs, currently includes a traditional pillar stability program as well as the pillar stability formulations developed by the USBM (now NIOSH) regarding stability of pillars in longwall operations and stability of pillars in room and pillar retreat operations.

4.1 Pillar Design for Room and Pillar Operations

The pillar stability program uses data that describe mine geometry and overburden characteristics, as well as coal pillar strength, to calculate safety factors based on four well-accepted pillar design formulations, namely those proposed by Bieniawski, Holland, Holland-Gaddy, and Obert & Duvall.

The safety factors associated with the aforementioned pillar equations can be calculated using the pillar tributary area concept (Figure 4.1.1). Parametric graphs for

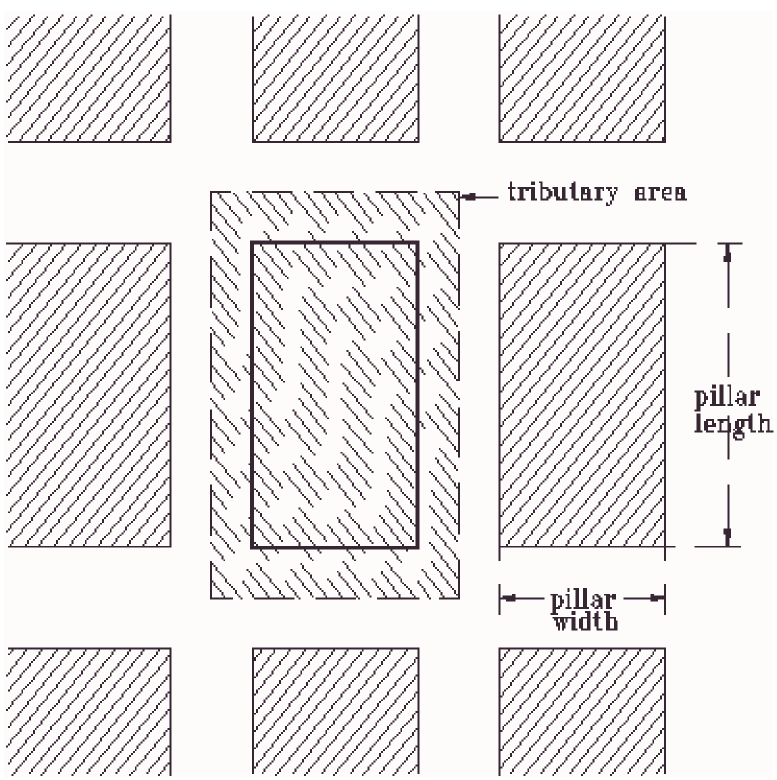


Figure 4.1.1: Pillar tributary area

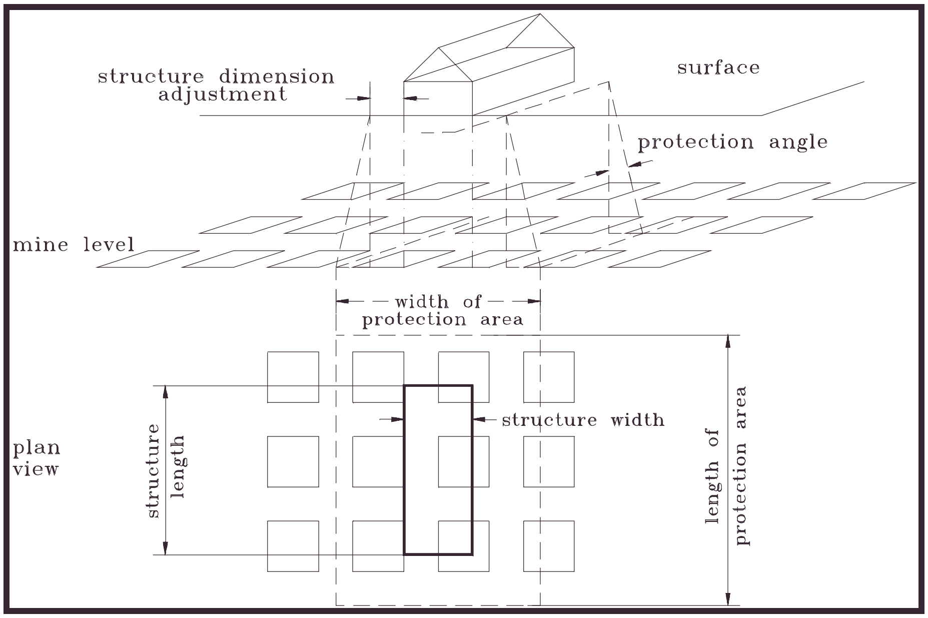


Figure 4.1.2: Protection area under a surface structure

the calculated safety factors can be generated for all formulations.

Also, the program can calculate the dimensions of the *protection area* (commonly referred to as “Pennsylvania Law”) a seam level underneath a surface structure. Extraction within this area should be limited if the surface structure is to be protected (Figure 4.1.2).

4.2 The ALPS Method

The ALPS program is a stand alone program that was developed by NIOSH and is freely distributed. It is included in the SDPS suite of programs to allow direct comparisons of pillar stability calculations. The program can calculate the ALPS stability factors, utilizing the widely accepted ALPS formulation for assessing pillar stability.

The ALPS method consists of three basic steps:

- Estimating the loading that will be applied to the pillars during all the phases of longwall mining;
- Estimating the load-bearing capacity of the longwall pillar system, and;
- Calculating *stability factors* (SF) by comparing the load to the load-bearing capacity.

Since its development, the ALPS method has been verified by back-analysis of more than 100 actual mining case histories (Mark, 1992). A complete discussion of the formulas used in ALPS can be found in that reference, copies of which are available from the author.

Recent research (Mark *et al.*, 1994) has shown that the ALPS SF used in design should be based on the structural competence of the mine roof, measured by the Coal Mine Roof Rating (CMRR). A complete description of the CMRR, including field data collection and procedures for calculating the ratings, have been provided by Molinda and Mark (1994). Spreadsheet programs for calculating the CMRR are also available (Riefenberg and Wuest, 1994).

Calculations are performed for two distinct modes:

- the analysis mode (or forward model)
- the sizing mode (or inverse model)

Analysis mode

The calculation phase of ALPS consists of several simple routines which compute the development loads, the abutment loads, the strengths and load-bearing capacities of the pillars, and the stability factors. The development loads, which are present before longwall mining, are determined by the depth of cover using the *tributary area* theory. Abutment loads occur as a portion of the weight of the overburden, that had been supported by the excavated longwall panel, is transferred to the pillars. They are determined by the depth of cover, the panel width, and the abutment angle.

ALPS calculates the unit strength of the pillars using Bieniawski's empirical pillar strength formula. The pillar strength is multiplied by load-bearing area and divided by the crosscut spacing to compute the load-bearing capacity per foot of gate entry. Then the load-bearing capacity of the longwall pillar system is obtained by summing the capacities of the individual pillars. Finally, stability factors are obtained by dividing the system's load- bearing capacity by the total loading.

In this mode, output consists of four (4) screens of data:

- ALPS stability factors
- Pillar load bearing capacity
- Design loadings on pillar system (load per length of gate entry)
- Individual pillar loading

The most important output provided by ALPS in the *analysis mode* are the stability factors. These are determined for five loading conditions:

- <u>Development loading:</u> The loading on the pillar system before any longwall retreat mining. It is equal to the tributary area load.
- <u>Headgate loading:</u> The pillar loading adjacent to headgate corner of the longwall face, which is equal to the development load plus the first front abutment.
- <u>Bleeder loading:</u> The loading on a pillar system adjacent to a mined-out panel, which equals the development load plus the first side abutment.

- Tailgate loading: The loading on a double-use gate entry system when it is adjacent to the tailgate corner of the longwall face, equal to the development load plus the first side abutment plus the second front abutment.
- Isolated loading: The loading on a pillar system located between two mined-out panels, equal to the development load plus two side abutments.

Since most gate entry systems are used twice, first as a headgate and then as a tailgate, the stability factor for **tailgate** loading is usually employed in design. That is why the results for tailgate loading are marked with asterisks (***) in the output. Single-use gate entries should be designed for either headgate or bleeder loading. As already indicated, a Stability Factor between 0.7 and 1.3 is usually appropriate for gate entries, depending on the CMRR.

The pillar load bearing capacity screen includes the following:
- pillar width,
- width-to-height ratio,
- the unit pillar strength calculated using the Bieniawski formula, and
- the pillar load-bearing capacity per foot along the length of the gate entry.

The total pillar system load-bearing capacity, which is the sum of the load-bearing capacities of the individual pillars, is the parameter that is needed to compute the SF. It is compared directly with design loadings that are also provided.

In the *analysis* mode, the last output screen provides estimates of the loadings applied to the individual pillars in the gate entry system. The initial development loadings are calculated using tributary area theory, and the subsequent abutment loadings are added using the exponential stress decay formula developed in IC 9247, pp. 8-9. As noted in the output, the individual pillars loadings do not consider load transfer due to pillar yielding. In general, if the applied stress exceeds a pillar's strength, load transfer may be assumed to occur. No estimates of individual pillar loads are provided for the "tailgate" and "isolated" loading phases, because the field data available from those phases is not sufficient for the development of general formulas.

Sizing mode

In the *sizing mode*, ALPS will calculate the pillar size required to achieve desired stability factors that are entered by the user. The user must choose a longwall pillar configuration from three options:

- a three-entry system employing equal-sized pillars;
- a three-entry system employing a large "abutment" pillar and a small "yield" pillar, (Yield-Abutment, YA), and;
- a four-entry system employing a single large "abutment" pillar and two small "yield" pillars (Yield-Abutment-Yield, YAY).

If either the "YA" or "YAY" options are chosen, ALPS requests the width of the "yield" pillar. In this case the actual pillar width, rather than the center-to-center entry spacing, is required.

ALPS also requires "stability factors" (SF) for the sizing mode. The suggested SF depends on the CMRR for the case being analyzed, and ranges from approximately 0.7 for strong roof (CMRR=75) to 1.3 for weak roof (CMRR=35).

In the *sizing mode*, ALPS computes the pillar widths that are necessary to achieve the desired stability factors. A secant variation of Newton's root-solving algorithm is used to solve the following equation, in which the pillar width is the only unknown:

$$0 = SF - (B/L)$$

In the equation SF is the stability factor, B is the pillar system load-bearing capacity, and L is the design loading. The algorithm terminates when successive iterations have converged on a pillar width to within 0.1 ft.

In this mode, output consists of four (4) screens of data:

- ALPS pillar sizing results
- Pillar load bearing capacity
- Design loadings on pillar system (load per length of gate entry)
- Individual pillar loading

In the *sizing* mode, ALPS prints the pillar widths which will provide the specified stability factors for the specified design type. The pillar lengths are also given, because ALPS will automatically increase the crosscut spacing to maintain square pillars if the required pillar width exceeds the user-specified crosscut spacing. Also, as noted on the printout, the pillar widths and lengths are actual dimensions, not centers.

The remaining 3 screens of output data are similar to those described above for the analysis mode.

If the Coal Mine Roof Rating (CMRR) is known or can be estimated, the user simply inputs the proper CMRR, and the program returns a suggested ALPS SF using the formula:

$$\text{ALPS SF} = 1.76 - 0.014\ \text{CMRR}$$

According to Mark *et al.* (1994) this equation was derived from evaluations of tailgate performance at more than 60 U.S. longwalls.

The CMRR library is a text file that contains summaries of roof descriptions and CMRR values obtained from 97 locations. The library helps users estimate the CMRR when data is not available, and it allows users to check their own CMRR estimates against observations already made. More complete descriptions of the same 97 observations may be found in the appendix to Molinda and Mark, 1994.

4.3 The ARMPS Method

The ARMPS program is a stand alone program that was developed by NIOSH and is freely distributed. It is included in the SDPS suite of programs to allow direct comparisons of pillar stability calculations. The program can calculate the ARMPS stability factors, utilizing the ARMPS formulation for assessing pillar stability.

Preventing pillar squeezes, massive pillar collapses, and bumps is critical to the safe and efficient retreat mining of coal. To help prevent these problems, the U.S. Bureau of Mines (now NIOSH) developed the Analysis of Retreat Mining Pillar Stability (ARMPS) computer program. ARMPS calculates Stability Factors (SF) based on estimates of the loads applied to, and the load bearing capacity of pillars during retreat mining operations. The program can model the significant features of most retreat mining layouts, including angled crosscuts, varied spacings between entries, barrier pillars between the active section and old (side) gobs, and slab cuts in the barriers on retreat. It also features a pillar strength formula that considers the greater strength of rectangular pillars. The program may be used to evaluate bleeder designs as well as active workings.

A database of 160 pillar retreat case histories has been collected across the United States to verify the program. It was found that satisfactory conditions were very rare when the ARMPS SF was less than 0.75. Conversely, very few unsatisfactory designs were found where the ARMPS SF was greater than 1.5.

The loadings applied to the Active Mining Zone (AMZ) include development loads, abutment loads, and loads transferred from barrier pillars. The development loads, which are present before retreat mining, are determined by the depth of cover using the "tributary area" theory. Abutment loads occur as a result of retreat mining and gob formation. They are determined by the depth of cover, the width of the extraction front, the gob extents, and the abutment angles. The abutment loads are assumed to be distributed following the abutment load distribution function. Only the portion of the front abutment load that falls within the AMZ is included in the calculation of the SF. Loads are also applied to barrier pillars, but if the barriers are too small, there are three ways in which loads may be transferred to the AMZ:

- A portion of the side abutment load may be transferred according to the abutment load distribution function.
- If the barrier pillar yields, a portion of the side abutment load may be transferred, and;
- Front abutment loads may be transferred from yielded remnant barrier pillars inby the pillar line.

Loadings that can occur in ARMPS are:

- Development: Loading Condition: 1, 2, 3, 4

- Front Abutment: Loading Condition: 2, 3, 4
- Side Abutments: Loading Condition: 3, 4

- Transfer From Remnant Barriers: Loading Condition: 3, 4

Stability factors are obtained by dividing the total load-bearing capacity of the AMZ by the total load applied to it.

The next, critical step is the interpretation of the stability factor. The ARMPS method has been verified through back analysis of pillar recovery case histories. To date, more than 200 case histories have been obtained from 10 states, almost all from mine visits. They cover an extensive range of geologic conditions, roof rock cavability characteristics, extraction methods, depths of cover, and pillar geometries. Ground conditions in each case history have been categorized as being either satisfactory or unsatisfactory. Pillar failures responsible for unsatisfactory conditions included:

- Pillar squeezes;
- Massive pillar collapses, usually accompanied by airblasts, and/or;
- Coal pillar bumps.

Current research has begun to evaluate other factors that may contribute to satisfactory conditions when the ARMPS SF falls between 0.75 and 1.5.

4.3 Example #15: Calculations Using the Pillar Stability Analysis Module - Estimation of Pillar Safety Factors

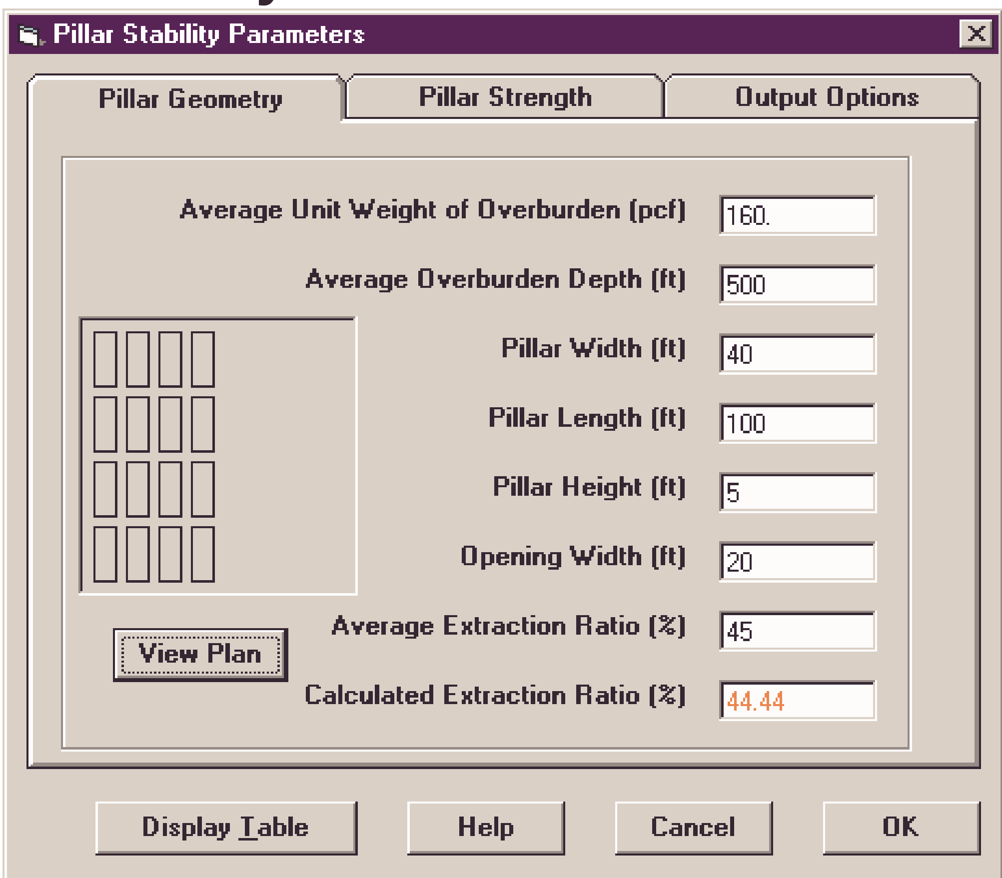


Figure 4.3.1: Pillar geometry parameters

Instructions

1. Execute the Pillar Stability Analysis Module.
2. Select the **Edit - Pillar Stability** option.
3. Enter the following parameters (Figure 4.3.1):
1. overburden depth = 500 ft
    - pillar width = 40 ft
    - pillar length = 100 ft
    - pillar height = 6 ft
    - opening width = 20 ft
    - average extraction ratio = 45 % (note that the tributary area extraction ratio is automatically calculated and displayed in red)
2. Click on the **View Plan** button to see a plan view of the mine section defined.
3. Click on the **Pillar Strength** tab of the current form (Figure 4.3.2).
4. Enter the value for pillar strength (e.g. 900 psi).
5. Click on the **Output Options** tab to select the form of the output, i.e. either table or graph. In the case of a graph output, the user can select between four parametric graphs (Figure 4.3.3).
6. Click on **Display Graph** and a

graph of all four pillar strength formulas will be plotted on the screen (Figure 4.3.4).

7. Close the viewing window.
8. Click on the **OK** button to accept the data.
9. Select the **File - Save** menu item.

Notes for Advanced Users:

1. Optionally the user can use the "Advanced Geometry" option and enter the pillar geometry in terms of number of entries, center-to-center distance between entries and center-to-center distance between crosscuts. The results are similar but the extraction ratio is calculated as an average on all entries.
2. The range for the parametric graphs is based on a percentile maximum and minimum values as defined in the **Utilities-Options** menu item.

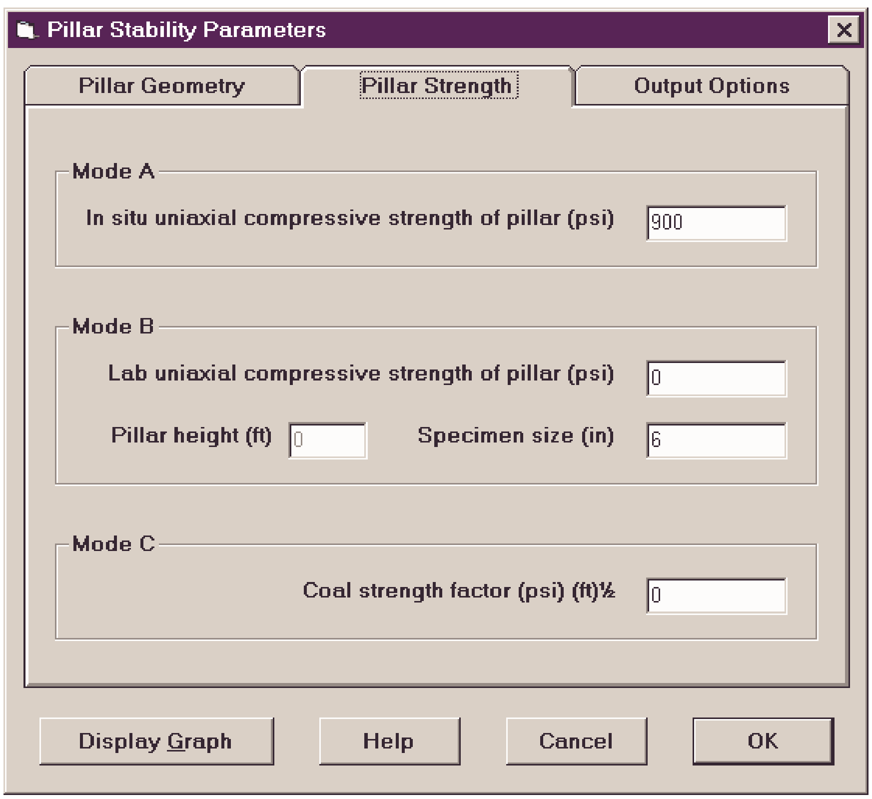


Figure 4.3.2: Pillar strength parameters

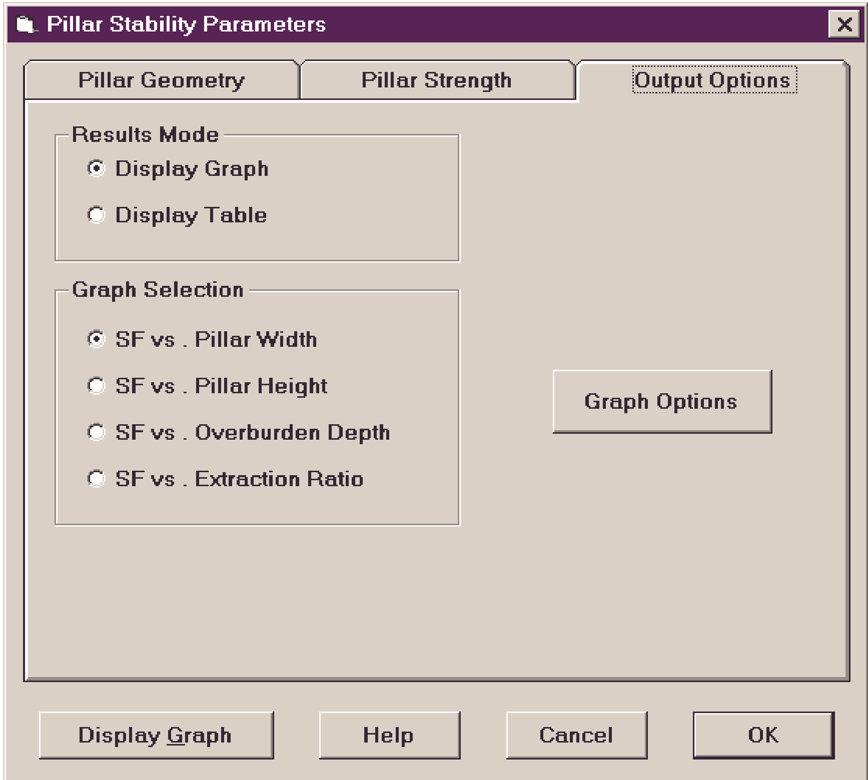


Figure 4.3.3: Output options

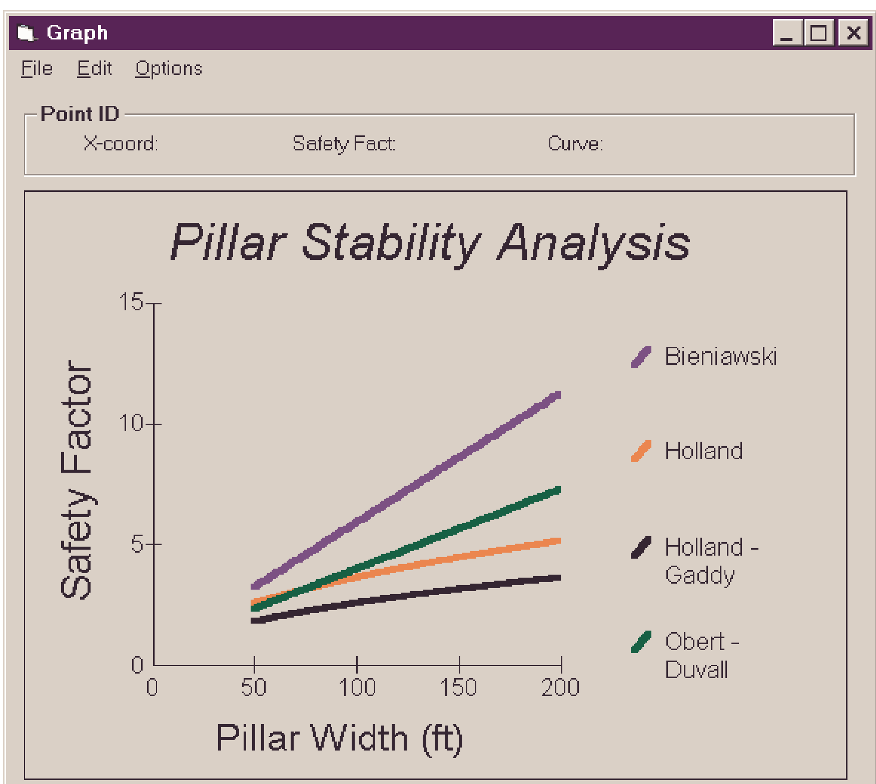


Figure 4.3.4: Parametric graph for four pillar strength formulas

4.4 Example #16: Calculations Using the Pillar Stability Analysis Module - Estimation of Protection Area

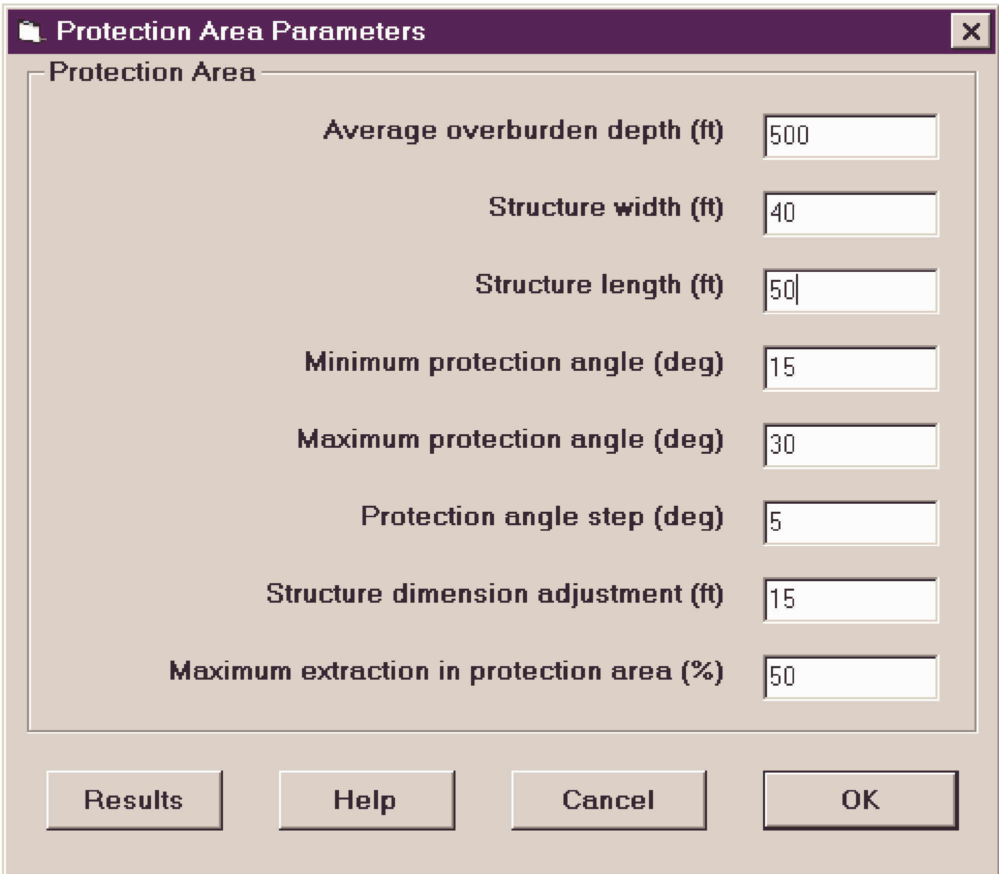


Figure 4.4.1: Structure and protection area geometry

Instructions

1. Execute the Pillar Stability Analysis Module.
2. Select the **Edit - Protection Area** option.
3. Enter the following parameters (Figure 4.4.1):
   - overburden depth = 500 ft
   - structure width = 40 ft
   - structure length = 50 ft
   - keep the default values for the remaining parameters
4. Click on the **Results** button.
5. The tabulated results will appear on the screen (Figure 4.4.2).

Note:
The extraction area is based on the assumed recovery, in this example, 50%. Using an appropriate seam thickness, this can be converted to extraction volume and tonnages.

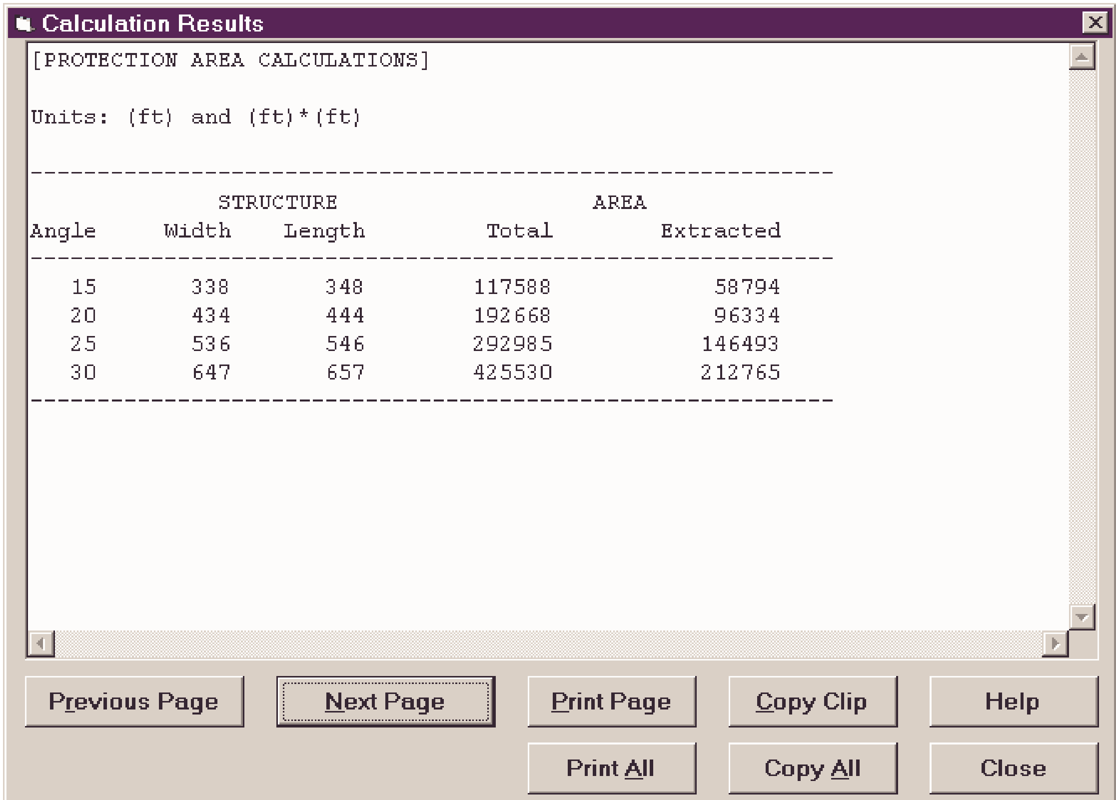


Figure 4.4.2: Protection area results

4.5 Example #17: Calculations Using the ALPS Module - Estimation of ALPS Stability Factors

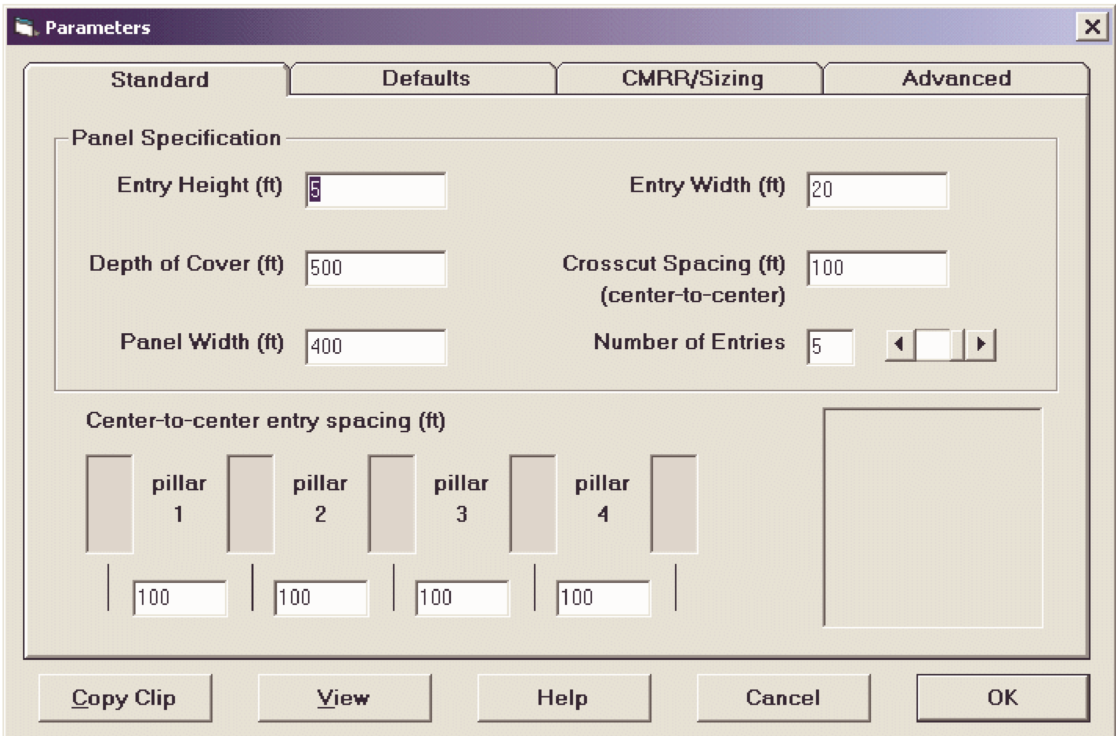


Figure 4.5.1: ALPS stability factors

Instructions

1. Execute the ALPS Module.
2. Select the **Input - Project Parameters** option.
3. Enter the mine geometry parameters as shown in Figure 4.5.1.
4. Keep the default load parameters.
5. Click on **OK** to exit the edit form.
6. Select the **Output - Stability Factors (Standard Geometry)** menu option.
7. The tabulated results will appear on the screen (Figure 4.5.2).
8. Select the **Output - Graph (ALPS Classic)** menu option.
9. Select the **SF vs Entry Height** option. The graph shown in Figure 4.5.3 will be created.
10. Close the forms and save the project.

Notes:

- The “Advanced” tab in Figure 4.5.1 allows for entering slanted crosscut entries (Figure 4.5.4).

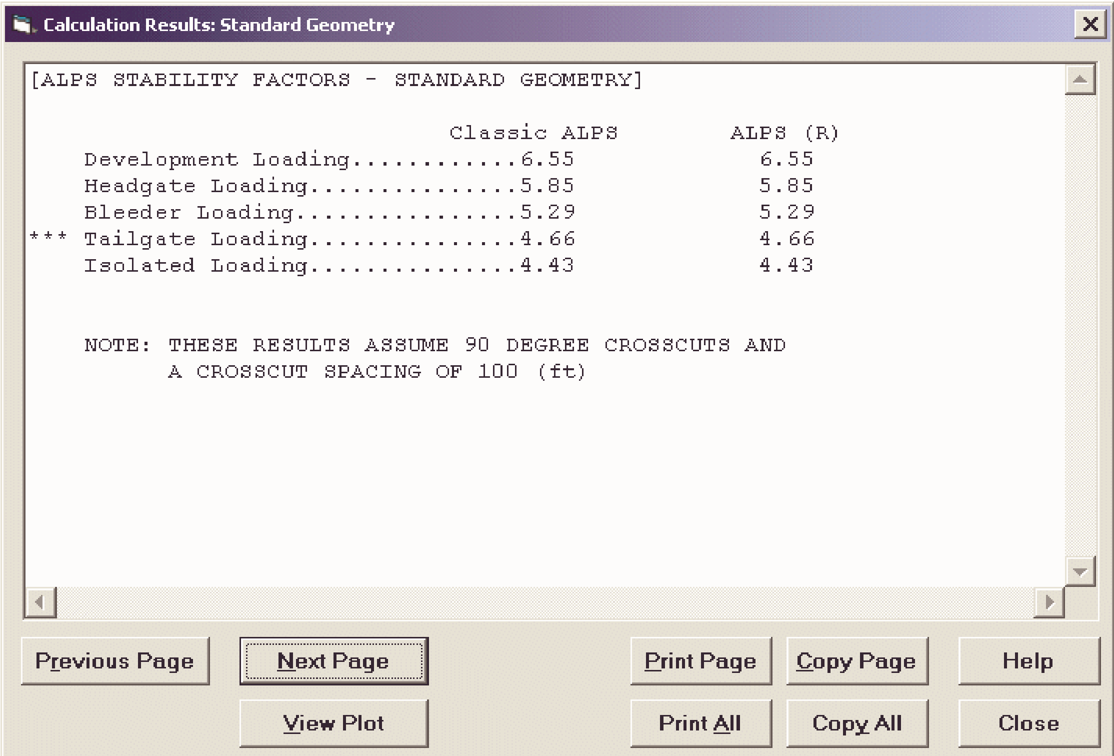


Figure 4.5.2: ALPS results

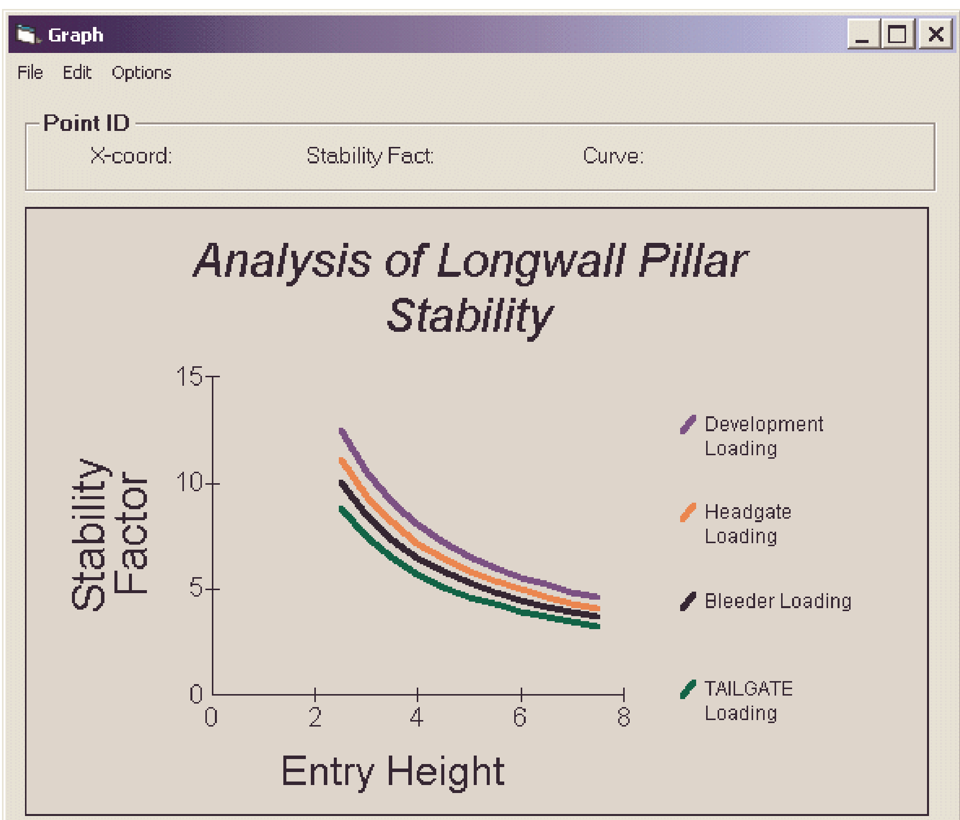


Figure 4.5.3: Parametric graph for ALPS stability factors

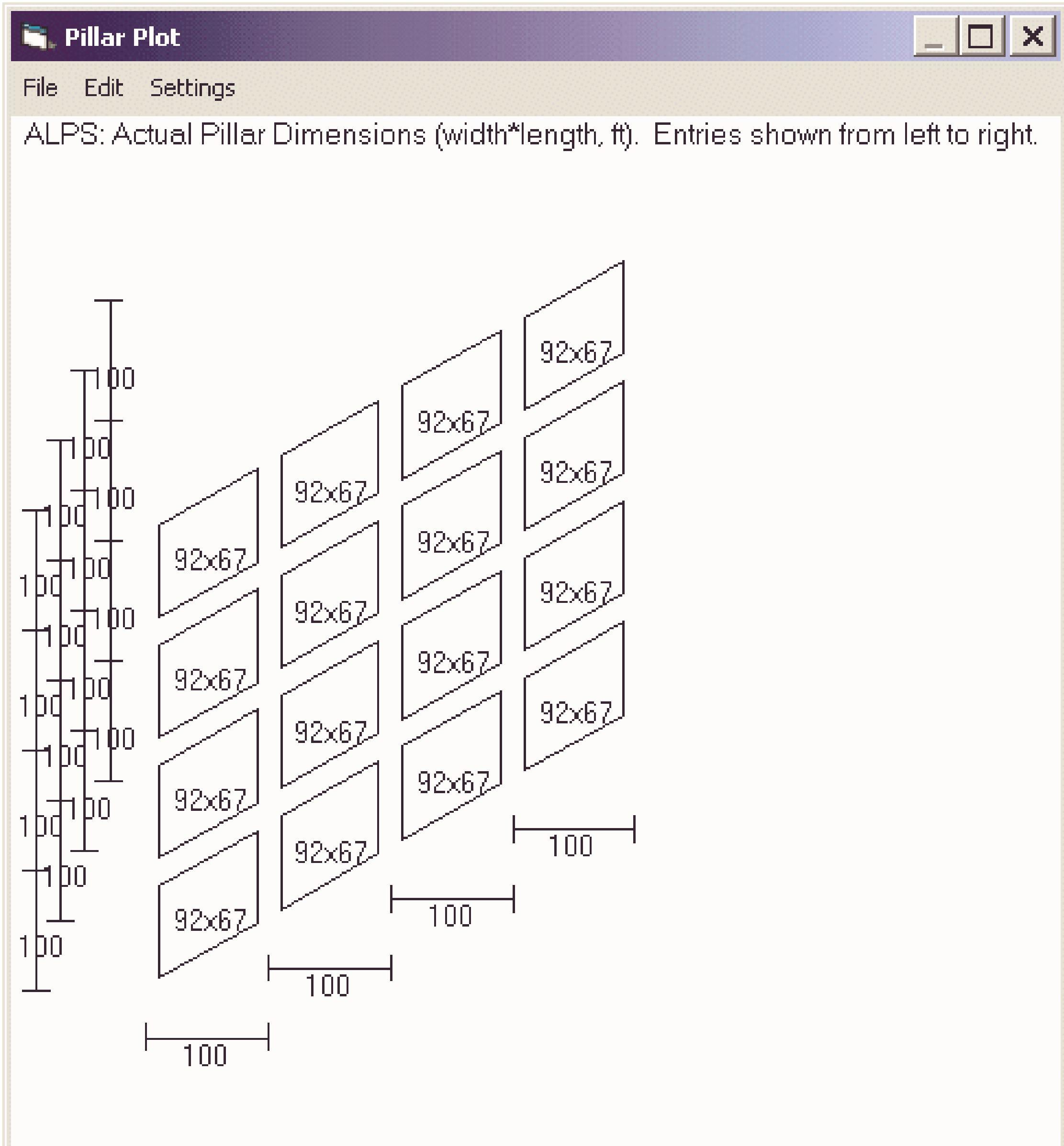


Figure 4.5.4: ALPS: Advanced geometry

4.6 Example #18: Calculations Using the ARMPS Module - Estimation of ARMPS Stability Factors

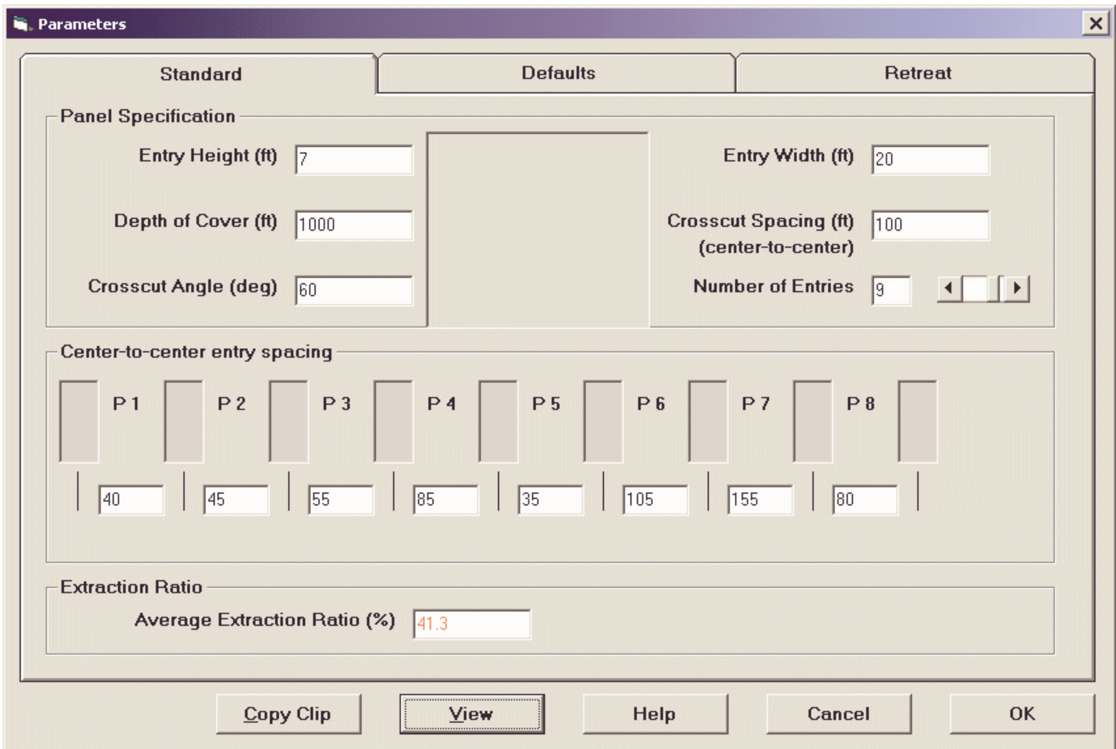


Figure 4.6.1: ARMPS input parameters

Instructions

1. Execute the ARMPS Module.
2. Select the **Input - Project Parameters** option.
3. Enter the mine geometry parameters as shown in Figure 4.6.1. Click on **View** to plot the mine plan on the screen (Figure 4.6.2).
4. Keep the default load parameters.
5. Click on **OK** to exit the edit form.
6. Select the **Output - Stability Factors** menu option.
7. The tabulated results will appear on the screen (Figure 4.6.3).
8. Select the **Output - Graph** menu option.
9. Select the **SF vs Entry Height** option. The graph shown in Figure 4.6.4 will be created.
10. Close the forms and save the project.

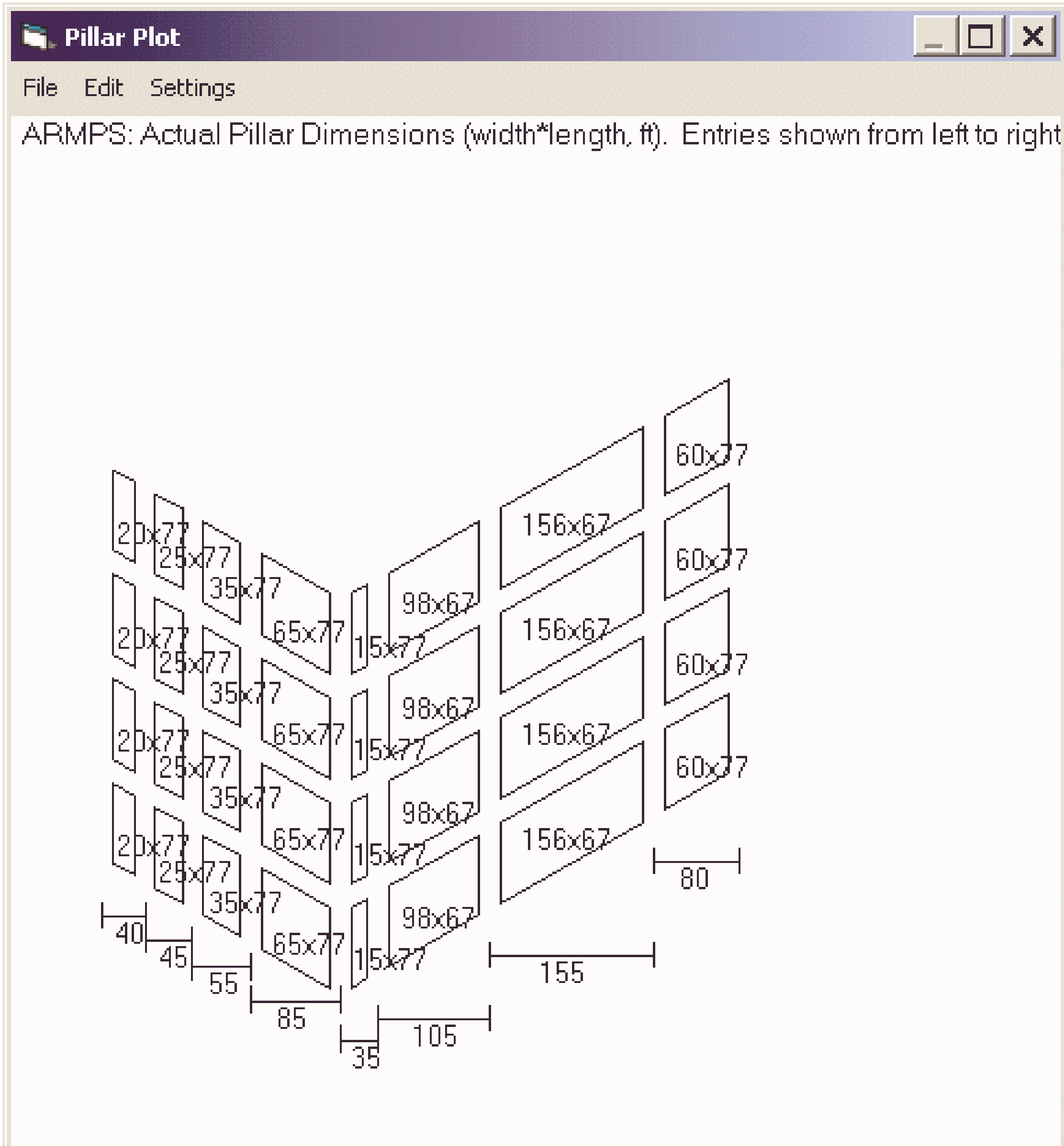
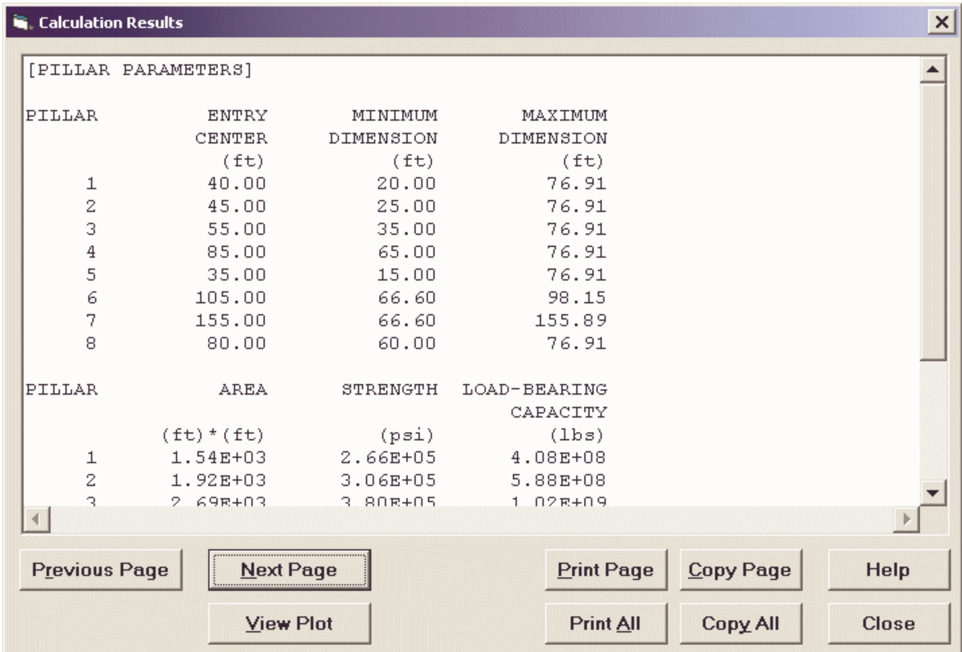


Figure 4.6.2: ARMPS: Plot of mine plan



Calculation Results

[PILLAR PARAMETERS]

PILLAR	ENTRY CENTER (ft)	MINIMUM DIMENSION (ft)	MAXIMUM DIMENSION (ft)
1	40.00	20.00	76.91
2	45.00	25.00	76.91
3	55.00	35.00	76.91
4	85.00	65.00	76.91
5	35.00	15.00	76.91
6	105.00	66.60	98.15
7	155.00	66.60	155.89
8	80.00	60.00	76.91

PILLAR	AREA (ft)*(ft)	STRENGTH (psi)	LOAD-BEARING CAPACITY (lbs)
1	1.54E+03	2.66E+05	4.08E+08
2	1.92E+03	3.06E+05	5.88E+08
3	2.69E+03	3.80E+05	1.02E+09

Figure 4.6.3: Results for ARMPS stability factors

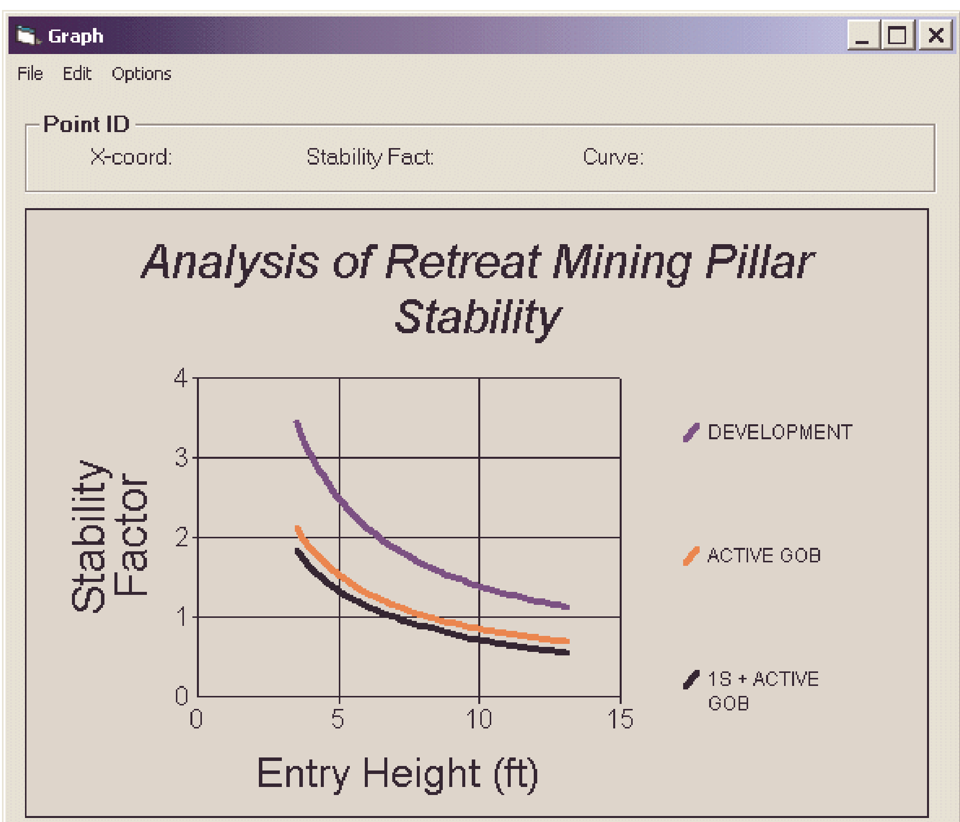


Figure 4.6.4: ARMPS: Parametric graph of stability factors

Chapter 5: The Graphing Module

This SPDS module can create two- and three-dimensional images of the calculated deformation indices and either display them on the screen or print them to a Windows device. The main source of input to this program are files created by the solution modules of the influence function method.

The program can handle two types of files:
- grid files (SDPS grid, Surfer grid and SurvCADD grid files)
- XYZ files

The points represented by a grid file are the points defined at the cross-section of horizontal and vertical grid lines within the grid boundaries. Thus, grid files contain the following information:
- the minimum and maximum extent in the x-direction
- the minimum and maximum extent in the y-direction
- the step size in the x- and y-directions
- the number of grid lines in the x- and y-directions
- the value for the z-parameter, i.e. values for a particular deformation index, the elevation, etc. for all points defined by the grid.

Notes:
Grid files do not contain the x- and y-coordinates for each point, since these values can be generated based on the above data.

5.1 Two-Dimensional Images: Cross-sectional plots

Cross-sectional plots generated from grid files can be defined along any (horizontal or vertical) grid line at any intercept. Depending on the orientation of the cross-section, the x-axis of the graph will represent either the x- or the y-axis of the grid. The y-axis of the graph will always be the z-parameter for the corresponding points. The user has the option to view cross-sections created at different intercept values either on the x- or y-direction.

When data are available in an XYZ file, which may or may not be defined on a regular grid, the program can only create one cross-sectional plot, which is termed a directional cross-section. This plot includes all points in the file taken in the sequence read from the file, i.e. from first to last. The file specified for the profile should only contain either two or three columns of data. If the file contains two columns of data, then the program assumes that the first is the x- and the second is the y-coordinate of the points to be plotted on the cross-sectional plot. These points are plotted directly without any scaling. If the file contains three columns of data, then the program assumes that it is an XYZ file. In this case the user has three options:

- to use an X-projection (i.e. use the x- and z-columns)
- to use a Y-projection (i.e. use the y- and z-columns)
- to use an Axial projection, in which case the origin of the x-axis is set to zero (0) and the distance between the points is the actual horizontal (radial) distance.

5.2 Two-Dimensional Images: Vector plots

Vector plot can be created only for those indices where a direction of a horizontal vector representing this index is available. For example vector plots can be plotted for the horizontal displacements, for the principal horizontal strains, for the principal horizontal curvatures as well as for the slopes.

5.3 Three-Dimensional Images

The program can also create three-dimensional graphs. These graphs can only be generated if deformation have been calculated on a grid. External gridding packages (such as Surfer or SurvCADD) can be used to grid the prediction points, prior to calculations.

Notes:
The graphing module can **not** directly load individual files for plotting. Files are loaded indirectly utilizing project information generated by the Influence Function Method.

Chapter 6: References

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Appendix 1: Program Reference

This section includes a detailed reference for the menu options for each program module.

A1.1 The Profile Function Module

A1.1.1 The File Menu

Use the File menu option to access various file management operations such as:

1. ***Create New Files***
   - Use the New option to erase the existing dataset (if any) from memory and create a new (blank) dataset. All related entries are set to their initial values. Note that the program will prompt you whether to save the current file to disk.
2. ***Open Existing Files***
   - Use the Open option to load a file (dataset) from the disk into program memory. To use Open:
     i. Select the Open option from the File menu. The program displays a listing of the available files in the current data directory.
     ii. Optionally, select a different drive or directory using the mouse or the cursor control keys.
     iii. Select or enter a filename.
   - Notes:
     i. If the file extension is omitted, the default extension will be appended.
     ii. If the current dataset is not saved, the program will prompt whether to save changes or not before discarding the current dataset.
3. ***Save Files***
   - Use the Save option to save an existing file (dataset) to the drive or directory from which it was originally loaded. Any changes that were made, since the last time the file was saved, will be saved on the disk. The filename stays the same and the file remains in memory. To use Save:
     i. Select the Save option from the File menu.
   - Notes:
     i. If the file has never been saved using the Save As option, choosing Save automatically displays the Save As dialogue box, which prompts for a filename before saving it.
4. ***Save Files under Different Names (Save As)***
   - Use the Save As option to save a file and give it a new name. To use Save As:
     i. Select the Save As option from the File menu. The program displays a listing of the available files in the current data directory.
     ii. Optionally, select a different drive or directory.
     iii. Select or enter a filename.
   - Notes:
     i. If the file exists, the program will prompt whether to overwrite the existing file.
     ii. Use Save for a faster save operation.
5. ***Print Files***
   - Use the Print option to print the current dataset (file) from program

memory to the printer.

- Notes:
  - i. This operation does not send any control characters to the printer. All output is ASCII text. All printed text will appear in the default printer font.
  - ii. The default values for paper margins are:
    left margin = 1 inch
    top margin = 1 inch
    bottom margin = 1 inch

6. ***Browse Text Files***
   - Use the Browse option to view a text (ASCII) file in a specified directory. Both an <u>internal</u> or an <u>external</u> browser can be used to browse such files. No editing is allowed during browsing using the internal browser.
   - Use the pattern field to specify a file pattern (i.e. *.txt). The file window will be reset to conform to the specified pattern. The default pattern is *.*.
   - More than one patterns can be applied using ";" as delimiter (e.g. *.txt;*.dxf).
   - Use the *Set Font* command button to specify the type and size of font for the displayed text in the internal browser. These settings are saved in the module.INI file.
   - Use the cursor control keys to move within the browse window.
   - If an external ASCII viewer is used (i.e. NOTEPAD.EXE) as specified in the Utilities-Settings form, then the maximum file size to browse is set by the limits of the external browser.
   - Notes:
     - i. The internal browser has a limit of approximately 25000 characters.
7. ***Exit the Program***
   - Use the Exit option when ready to exit this program and return to the original environment. The program will prompt you to save the current file to disk, if not already saved.

A1.1.2 The Edit Menu

Use the Edit menu option to access various data input, data editing operations and data graphing operations such as:

1. ***Project Description***
   - This is an arbitrary 300 character description of the model being generated. It is a good idea to make this a fairly detailed description of the specifics of the input file. This text may be a single line of characters or may contain "carriage return characters".
   - The user can also set the type of units that will be used in the current project. The program is designed to use two different sets of units: ft and m.
2. ***Profile Function Input Parameters***
   - The profile function method uses data that describe mine geometry and overburden characteristics to generate a profile of surface subsidence due to underground mining. The formulation assumes uniform excavation conditions and calculates subsidence for each half-panel. The following

parameters are necessary for the calculations:

i. Subsidence Parameter Data: which includes:

(1) The mining system: A longwall or a room-and-pillar mining system can be selected. If a longwall system is selected, the extraction ratio input field is disabled and the extraction ratio is internally assumed 100%.

(2) The panel width: The least panel dimension should be specified as panel width.

(3) The panel depth (depth of cover or overburden depth): The depth of cover to the top of the seam should be specified.

(4) The extraction thickness (seam height, mining height): The term extraction thickness reflects the total thickness mined, not just the seam thickness.

(5) The extraction ratio: This parameter can only be specified for room-and-pillar panels. The lower limit currently accepted is 75%.

(6) The percent hardrock in the overburden (%HR): This parameter can be determined by calculating the % of competent strata in the overburden (i.e. limestone, sandstone beds, etc.)

(7) The surface point spacing: This parameter is used to define the spacing of the surface points for calculating the subsidence profile. The points are assumed on a transverse line starting from the panel center.

(8) The prediction mode: This parameter specifies the type of prediction equation to be used. The conservative equation gives an envelop line, while the average equation gives a prediction which is based on the statistical average of the database.

(9) The definition of zero subsidence: These parameters are used to define the point to be considered as point of zero subsidence. This can be defined either as a percentage of the maximum subsidence value or as a fixed value (ft or m). The angle of draw may be calculated based on these values.

ii. Output Options: These options include:

(1) Results mode: This option allows the user to select whether to the results in the form of graph (Display Graph) or in the form of a table (Display Table). The default "results mode" may be set through the Profile Function Program Options.

(2) Graph mode: This option is enabled only when the Display Graph option is selected and allows the user to select whether the graph will display only one curve at a time (Single Curve) or the graph engine will allow overlaying of profiles (Append Curve) up to the maximum number specified in the graph options form. The default "graph

mode" may be set through the Profile Function Program Options.

(3) Show Angles from the Rib: This option is enabled only when the Display Table option is selected and allows the user to select whether the angles from the rib to each surface point on the surface will be calculated. This is an indirect way to calculate the angle of draw, where the user makes the choice of the cutoff (zero subsidence) point.

(4) Plot Angles of Draw: This option is enabled only when the Display Graph option is selected and allows the user to select whether the angle of draw corresponding to each curve will be plotted on the graph. Note that this option is automatically disabled when one or more curves are plotted on the screen. In other words, the user can not select or deselect this option in the middle of a graphing session. To enable the option, either clear the current graph or close the graph window and recreate the last graph.

3. ***Basic Graph Formatting Options*** (applies to more than one modules)

- The user can set the basic graph formatting parameters such as:
  - i. The graph title: The graph title is a text string placed over the graph.
  - ii. The graph x-axis title: The x-axis title is a text string placed below the x-axis of the graph.
  - iii. The graph y-axis title: The y-axis title is a text string placed to the left of the y-axis of the graph.
  - iv. The grid style: Four grid styles are available: Horizontal lines, vertical lines, horizontal and vertical lines, no grid lines.
  - v. The graph style: Three graph styles are available: lines, symbols, lines and symbols.
  - vi. The maximum number of curves: The user can specify the maximum number of curves that can be overlaid on the graph. When this number is exceeded (in the Append Curve mode) the program will instruct the user to clear the graph before proceeding.
  - vii. The curve legend: This option enables or disables the legend box in the graph. When this options is enabled, The combination of a scroll box and a text box allows the user to modify the default legend titles for all graphs on the screen.
  - viii. Symbol size: With this scroll box the user can set the size of the symbols used by the graph object. The scroll box is enabled only for a graph type of "symbols" or "lines and symbols".
  - ix. Default parameter options: There are two default parameter options: a) to set the default parameters (i.e. graph title, x-axis title, etc.) every time the graph options form is invoked, and b) to set the format parameters to used in the previous graphing session. These values are saved in the corresponding module.INI file.

4. ***The Graph Form*** (applies to more than one modules)

- This form is used to display a graph generated by the calling program. The menu options available are:
    - i. [File Import]: This option imports data to the graph from a space or tab delimited file. This option is not available in all modules.
    - ii. [File Export]: This option saves the data in the graph in a space or tab delimited file. This option is not available in all modules.
    - iii. [File-Save]: This option saves the graph as an image file. The image file is in WMF format (Windows Metafile). This option is not available in all modules.
    - iv. File-Print: This option prints the graph to the default printer.
    - v. File-Exit: This option clears the graph and closes the graph form.
    - vi. [File-Exit and Keep]: This option hides the graph form. The form is shown again when the graphing routines are called. Graphs are preserved between calls. This option is not available in all modules.
    - vii. Edit-Copy: This option copies the current graph object to the clipboard for use in other applications.
    - viii. [Edit-Clear]: This option clears the graph and allows plotting of more curves. This option is not available in all modules. Note that although the graph is cleared from the screen, the graph parameters are kept internally. A number of options, such as enabling or disabling the graph tool bar or invoking the options form, will restore the graph to the screen.
    - ix. Options-Graph Toolbar: This option enables the graph tool bar. Using the graph toolbar the user has more choices regarding the appearance of the graph than those provided by the basic graph formatting options. The options in the graph toolbar have their own on-line help file. This option is disabled by default.
    - x. Options-Point ID: This allows the user to click on a point a curve on the graph and the coordinates of this point will be displayed in the appropriate boxes.
    - xi. Options-Basic Options: This option loads the graph options form which includes basic graph formatting options.
- Notes:
    - i. Command buttons available on some forms are specific to each module and are usually self explanatory.
    - ii. Graphics support is provided by Graphics Server 4.53, which is an independent graph control not included in the Microsoft Visual Basic 4.0 package.

A1.1.3 The Utilities Menu

Use the Utilities menu option to access various program options such as:

1. ***Settings*** (applies to more than one modules)
    - This form is used to define a number of default parameters and settings for the program:
        - i. Default Units: This setting controls the default units' selection used when the program is executed. This setting is also used as an

initial value in the Project Description form. This setting is saved in the module.INI file.

ii. Default File Extension for Input Files: This setting is the default 3-letter extension used in the Open and Save dialog boxes in the File Menu. This setting is saved in the module.INI file.

iii. Data Path: This setting is the default path used in the Open and Save dialog boxes in the File Menu. This setting is saved in the module.INI file.

iv. Display Command History Window: This parameter controls whether the program will display recently executed commands (and their resulting actions). This setting is saved in the module.INI file.

v. Maximum Characters in Command History Window: Maximum number of characters displayed in the command history window, before it is cleared. This setting is enabled only if the Display Command History Window option is enabled. This setting is saved in the module.INI file.

vi. Font Type and Size in Command History Window: This button sets the type and size of font used in the command history window. This setting is enabled only if the Display Command History Window option is enabled. This setting is saved in the module.INI file.

vii. Keep Recently Accessed File Names: This parameter controls whether the program will keep up to four (4) recently accessed data files (opened or saved) as menu items in the File Menu. This setting is saved in the module.INI file.

viii. Show Disclaimer: This parameter controls whether the disclaimer message will be displayed when loading the program. This setting is saved in the module.INI file.

ix. Maximize Main Menu Window: This parameter controls whether the main menu window will be maximized when loading the program. This setting is saved in the module.INI file.

x. Enable Toolbar: This parameter controls whether the main menu toolbar will be enabled when viewing the main menu. This setting is saved in the module.INI file.

xi. External Viewer: The user can set the application name of an external ASCII viewer for viewing reports and other ASCII files generated by the program. The default viewer in NOTEPAD.EXE supplied with the windows operating system. Note that prior to Windows2000, NOTEPAD.EXE could only edit / display files up to 64K. This setting is saved in the module.INI file.

2. ***Options***

- This form is used to define a number of default parameters and options pertaining specifically to the Profile Function Method Module. These options include:

i. General

(1) Load Input Screen on File Open: This option will load the main parameter input screen when the user selects File -

Open (filename) or File - New.

(2) Print Module Version Information: This option will enable printing of a module header when a print function is executed.

(3) Warn User When Input Data Outside Usual Range: When this option is enabled, then warning messages will be issued if input data are outside usual range. This option does not affect data that exceed absolute limits.

ii. Default Settings

(1) Show Angles from the Rib: This option will set the default option for displaying (or not) angles from the rib when results are shown in table form.

(2) Plot Angles of Draw: This option will set the default option for ploting an angle of draw when graphing the calculated profile.

(3) Default Results Mode: This option will set the default results mode in the main parameter input screen (display graph or display table)

(4) Default Graph Mode: This option will set the default graph mode in the main parameter input screen (append curve or single curve)

3. ***Unit Conversions*** (applies to more than one modules)

- This utility can be used to convert between English and metric units for 4 types of units:

  i. Length: Conversion between feet, inches, meters and centimeters is supported.

  ii. Pressure: Conversion between psi (pounds per square inch), Pa (Pascals) and MPa (MegaPascals) is supported.

  iii. Stress (Pressure) Gradient: Conversion between psi/ft (psi per foot), psi/in (psi per inch), MPa/m (MegaPascal per meter) and Pa/m (Pascal per meter) is supported.

  iv. Load Gradient: Conversion between lbs/ft (pounds per foot), lbs/in (pounds per inch), kN/m (kiloNewton per meter) and MN/m (MegaNewton per meter) is supported.

- Notes:

  1 Pa = 1 Newton per square meter

  1 psi = 1 pound per square inch

4. ***Clear History Window*** (applies to more than one modules)

- This option clears the history (activity) window.

5. ***Close/Restore History Window*** (applies to more than one modules)

- This option closes or restores the history (activity) window according to the current window status.

6. ***Copy History Window*** (applies to more than one modules)

- This option copies the contents of the history window to the clipboard. You can then paste them to any text handling program for further processing.

A1.2 The Influence Function Module

A1.2.1 The File Menu

Use the File menu option to access various file management operations such as:

1. ***Create New Files***
   - This function has three options:
     i. Create New Project Files
     ii. Create New Mine Plan Files
     iii. Create New Prediction Point Files
   - Use the New option to load a blank dataset into program memory.
   - Creating a new project loads resets the default values for the type of mine plan, prediction points, units and overburden information.
   - Creating a new mine plan, resets the default values for the mine plan. Similarly, creating a new set of prediction points, resets the defaults values for the set. To use New:
     i. Select the New option from the File menu.
2. ***Open Existing Files***
   - This function has three options:
     i. Open Project Files
     ii. Open Mine Plan Files
     iii. Open Prediction Point Files
   - Use the open option to load a file (dataset) from the disk into program memory.
   - Opening a project loads saves the mine plan, prediction point and overburden information from a single file. Opening a mine plan loads just the mine plan geometry from a file. Similarly, opening the prediction points, opens just the prediction point geometry from a file. These last two features are very useful when creating sets of project files based on similar mine plans, but with different surface topography, or when using the same surface topography to create project files with different mine plans. To use Open:
     i. Select the Open option from the File menu. The program displays a listing of the available files in the current data directory.
     ii. Optionally, select a different drive or directory using the mouse or the cursor control keys.
     iii. Select or enter a filename.
   - Notes:
     i. If the file extension is omitted, the default extension will be appended.
     ii. If the current dataset is not saved, the program will prompt whether to save changes or not before discarding the current dataset.
3. ***Save Files***
   - This function has three options:
     i. Save Project Files
     ii. Save Mine Plan Files
     iii. Save Prediction Point Files

- Use the Save option to save an existing file (dataset) to the drive or directory from which it was originally loaded. Any changes that were made, since the last time the file was saved, will be saved on the disk. The filename stays the same and the file remains in memory.
- Use the Save As option to save an existing file (dataset) under a new filename specification.
- Saving a project saves the mine plan, prediction point and overburden information in a single file. Saving a mine plan saves just the mine plan geometry in a file. Similarly, saving the prediction points, saves just the prediction point geometry in a file. These last two features are very useful when creating sets of project files based on similar mine plans but with different surface topography, or when using the same surface topography to create project files with different mine plans. To use Save:
  i. Select the Save option from the File menu.
- <u>To use Save As:</u>
  i. Select the Save As option from the File menu.
- <u>Notes:</u>
  i. If the file has never been saved using the Save As option, choosing Save automatically displays the Save As dialogue box, which prompts for a filename before saving it.

4. ***Import Data***

- Use the File - Import option to import either an SDPS project created by SDPS version 4.x software or import SDPS components (i.e. mine plans and sets of prediction points) from other sources, mainly AutoCAD files. The import form (for SDPS components) has the following options:
- <u>Import a mine plan from an AutoCAD DXF file.</u> The user should specify the following:
  i. The layer names of active and hidden (not-active) entities. Default layer names are PANELS for extraction panels and PILLARS for pillars.
  ii. The type of the extracted area (longwall, high extraction room-and-pillar or low extraction room-and-pillar).
  iii. Whether to import elevations from the AutoCAD file or to use an average elevation as specified in the import form.
  iv. The subsidence parameters (subsidence factor or percent hardrock) associated with every point in each imported parcel.
  v. Whether to apply a scale factor to the coordinates imported from the AutoCAD file.
  vi. The thickness for every point in each imported parcel.
  vii. Whether to append the data to the existing set or start a new set.
- <u>Notes:</u> Importing will always result in a polygonal mine plan.
- <u>Import prediction points from an AutoCAD DXF file.</u> The user should specify the following:
  i. The layer names of active and hidden (not-active) entities. The default layer name is POINTS.
  ii. Whether to import elevations from the AutoCAD file or to use an

average elevation as specified in the import form.

iii. Whether to apply a scale factor to the coordinates imported from the AutoCAD file.

iv. Whether to append the data to the existing set or start a new set.

- Import prediction points from an XYZ (ASCII) file: The XYZ points option will import an XYZ ASCII data file as a scattered surface point set. The data can be either space-delimited or comma-delimited. The program will preview the data file and try to determine the number of header (text lines), if any, as well as the number of columns in the data set.
- <u>Import a set of prediction points from a Surfer grid file (ASCII).</u> The *grid from surfer* option will import a grid of surface points. The Surfer grid file should be in a DOS format and saved in ASCII. No options are needed for this function. All information will be retrieved from the grid file header.
- <u>Import a set of prediction points from a SurvCADD grid file.</u> The *grid from SurvCADD* option will import a grid of surface points. No options are needed for this function. All information will be retrieved from the grid file header.
- <u>Import points and/or panels and/or pillars directly from AutoCAD 2000 DWG files.</u> This selection invokes a new form with the following options:

i. Import points from contours. The user should specify the following:

(1) The file name of the AutoCAD file (DWG file) that holds the data. The program will read the file and import the layer names.

(2) The layer names of the CONTOURS as they can be selected from the combo box.

(3) The entity type for the contour lines. Here only two options are supported: LWPOLYLINE and 3DPOLYLINE.

(4) Whether to append the data to the existing set or start a new set.

ii. Import mine plan. The user should specify the following:

(1) The file name of the AutoCAD file (DWG file) that holds the data. The program will read the file and import the layer names.

(2) The layer names of the PANELS and the PILLARS as they can be selected from the combo boxes.

(3) The entity type for the contour lines. Here only two options are supported: LWPOLYLINE and 3DPOLYLINE.

(4) The subsidence factor associated with every point in each imported parcel.

(5) The thickness for every point in each imported parcel.

(6) Whether to append the data to the existing set or start a new set.

iii. Notes:

(1) The routine for reading directly from AutoCAD 2000 was originally designed by Steven J. Schafrik.

(2) If all input data is digitized to a single AutoCAD file (in

different layers) then the whole project can be imported in two steps. One step for the mine plan and one step for the prediction points.

(3) Surface topography contour lines can be imported as prediction points only through direct interaction with AutoCAD 2000.

(4) When importing data in a new project, the program will automatically switch the mine plan type and/or the prediction point type to one needed for the import. If, however, data are imported into an existing project, this process will have to be done manually by the user.

5. ***Export Data***

- Use the File - Export option to export either a whole SDPS project to AutoCAD DXF format or to export SDPS components to XYZ format. The export form has three options:
  - i. Export the current project to AutoCAD DXF format
  - ii. Export the current mine plan to XYZ point format
  - iii. Export the current surface points to XYZ point format
- In the case of AutoCAD output, the program will create a DXF file with the mine geometry information as well as the surface topography data saved in separate layers. Note that subsidence information as well as point id information is lost during this process.
- In the case of XYZ output all data is converted to XYZ coordinates and stored to files. Additional information such as point ids and subsidence data are preserved.

6. ***Print Files***

- Use the Print option to print an existing file (dataset) to any windows printer. This function prints the data as its currently in the computer memory. This function has three options
  - i. Print Project Files
  - ii. Print Mine Plan Files
  - iii. Print Prediction Point Files
- To use Print: Select the Print option from the File menu.
- <u>Notes:</u>
  - i. The file prints in the default printer font with a left margin of 1 inch and a top margin of 1 inch.

7. ***Browse Text Files***

- Use the Browse option to view a text (ASCII) file in a specified directory. No editing is allowed during browsing.
- Use the pattern field to specify a file pattern (i.e. *.txt). The file window will be reset to conform to the specified pattern. The default pattern is *.*.
- More than one patterns can be applied using ";" as delimiter (e.g. *.txt;*.dxf).
- Use the *Set Font* command button to specify the type and size of font for the displayed text. These settings are saved in the module.INI file.

- Use the cursor control keys to move within the browse window.
- <u>Notes:</u>
  i. The browser has a limit of approximately 25000 characters.

8. ***Exit the Program***
   - Use the Exit option when ready to exit this program and return to the original environment. The program will prompt you to save the current file to disk, if not already saved.

A1.2.2 The Edit Menu

The influence function formulation supports several different types of excavation geometry and prediction point layouts. Data that describe excavation geometry are referred to as mine plan data, while data that describe the points on the surface (or any other elevation), where deformation indices will be calculated, are referred to as prediction point data. Mine plan data can be specified as

- a sequence of closed polygonal lines (polygonal mine plans)
- rectangular entities parallel to the coordinate system (rectangular mine plans)

Prediction point data can be represented by:

- scattered points
- points on a grid oriented parallel to the coordinate system

Use the Edit menu option to access various data input, data editing operations and data graphing operations such as:

1. ***Project Description:***
   - This is an arbitrary 300 character description of the model being generated. It is recommended to make this a fairly detailed description of the specifics of the input file. This text may be a single line of characters or may contain *carriage return characters*.
   - The user can also set the type of units that will be used in the current project. The program is designed to use two different sets of units: ft and m.
   - When creating a project file, the user will have to specify the **type of mine plan and the type of prediction point data** that will be used. The following combinations may be selected:
     i. Polygonal Mine plan, Scattered Points
     ii. Polygonal Mine plan, Points on Grid
     iii. Rectangular Mine plan, Scattered Points
     iv. Rectangular Mine plan, Points on Grid
2. ***Mine Plan Data - Polygonal Mine Plans***
   - In this input form the user can specify or modify the geometry and characteristics of Polygonal Mine Plans. A mine plan may consist of one or more parcels (panels or pillars). Each parcel is constructed of points which should be entered in a **counter-clockwise** direction. Required parameters for each point include:
     i. the point reference code which can be any alphanumeric string,
     ii. the easting, northing and elevation of each point,
     iii. the extraction thickness at each point as well as the supercritical subsidence factor at that point (see tables),

iv. the parcel type, i.e. either panel or pillar,
v. the parcel status, i.e. active or not active (an inactive parcel will not be displayed in the View option and will not participate in any of the calculations)

- User Interface:
  - i. The information for a specific point or parcel can be accessed and/or modified by using either the sliding pointers or by entering the serial number of the parcel or point in the *Record Management* frame of the form.
  - ii. A new parcel (or new point within a parcel) may be created or an existing parcel (or point) may be deleted. The new parcel will be appended at the end of the parcel sequence (append mode). The location of any parcel in the parcel database does not affect its contribution to surface deformations. A parcel should contain a minimum of 3 points.
  - iii. If the "Auto Subs. Factor" check box is enabled, the program will automatically calculated the subsidence factor for the parcel depending on the value of the "R&P" check box.
  - iv. The *View All* command button will display a graph of the currently defined mine plan as well as the currently defined prediction points (if any). The *View* command button will display a graph (map) of the currently defined mine plan. The *Table* command button will load all points in the database in a spreadsheet type of table. This is considered an advanced editing feature and can be disabled or enabled through the options form.
- Notes:
  - i. The *cancel* command button will be changed to *close* if irreversible changes are made to the database. Such changes generally include editing of more than one point.
  - ii. The *Table* command button should be used by experienced users only, since changes may inadvertetly affect a range of points.

3. ***Mine Plan Data - Polygonal Mine Plans***

- In this input form the user can specify or modify the geometry and characteristics of Rectangular Mine Plans. A mine plan may consist of one or more parcels (panels or pillars). Each parcel is represented by a rectangle which is defined by the coordinates of the four boundary lines. Required parameters for each point include:
  - i. the parcel reference code which can be any alphanumeric string,
  - ii. the coordinates of the west, east, south and north,
  - iii. the parcel elevation,
  - iv. the extraction thickness and the supercritical subsidence factor for that parcel (see tables),
  - v. the parcel type, i.e. either panel or pillar,
  - vi. the parcel status, i.e. active or not active (an inactive parcel will not be displayed in the View option and will not participate in any of the calculations)

- <u>User Interface:</u>
  i. The information for a specific parcel can be accessed and/or modified by using either the sliding pointer or by entering the serial number of the parcel in the *Record Management* frame of the form.
  ii. A new parcel may be created or an existing parcel may be deleted. The new parcel may be appended at the end of the parcel sequence (append mode) or inserted at the current position (insert mode). The location of any parcel in the parcel database does not affect its contribution to surface deformations.
  iii. If the "Auto Subs. Factor" check box is enabled, the program will automatically calculated the subsidence factor for the parcel depending on the value of the "R&P" check box. In this case, the subsidence factor field is disabled and can not be edited directly.
  iv. Also, the edge effect at the ribs of the parcel may be considered. This can be implemented in detail through the *Subs. Parms* command button.
  v. The *View All* command button will display a graph (map) of the currently defined mine plan as well as the currently defined prediction points (if any). The *View* command button will display a graph (map) of the currently defined mine plan. The currently displayed parcel will be displayed in red on the map. The user may step through the parcels and visually check the location of each parcel.
  vi. The *Table* command button will load all parcels in the database in a spreadsheet type of table. This is considered an advanced editing feature and can be disabled or enabled through the options form.
- <u>Notes:</u>
  i. The *cancel* command button will be changed to *close* if irreversible changes are made to the database. Such changes generally include editing of more than one parcel.
  ii. The *Table* command button should be used by experienced users only, since changes may inadvertetly affect a range of parcels.
  iii. The insert/append option button determines the location of a new parcel within the database. *Insert* locates the new parcel before the current parcel, while *append* adds the parcel at the end of the list.

4. ***Subsidence Parameters for Rectangular Parcels***
- In this form the data pertaining to the subsidence parameters (i.e. the estimation of the edge effect around the rib of rectangular parcels of excavation, and the supercritical subsidence factor) can be specified for each parcel.
  i. If the adjustment option is set to "no adjustment" then the user can not change any of the input data.
  ii. If the adjustment option is set to "manual adjustment" then no automatic calculations can be performed. The user can enter

known parameters for each of these fields.

iii. If the adjustment option is set to "automatic adjustment" then automatic calculations are performed when the user changes any of the input parameters in this form.

- Input includes the state of the rib (yielding or solid) for each of the four ribs around the panel, the type of subsidence estimate and the panel depth and percent hardrock in the overburden.
- Also, the updated coordinates of the panel boundaries can be edited to be further adjusted.
- Notes:
  i. This option is not implemented for polygonal panels.
  ii. If the current parcel is a pillar, then this form will be displayed but no input values can be entered.

5. ***Prediction point data - Scattered Surface Points***

- In this input form the user can specify or modify the geometry of Scattered Surface Points. A scattered point set may consist of any number of points that are randomly located on the surface. If such points can be specified as part of a grid, then the Grid Points option should be used. Required parameters for each point include:
  i. the point reference code which can be any alphanumeric string,
  ii. the easting, northing and elevation of each point,
  iii. the point status, i.e. active or not active (an inactive point will not be displayed in the View option and will not participate in any of the calculations)
- The user can display/modify any point by using either the sliding pointers or by entering the serial number of the point in the *Record Management* frame of the form.
- Also, the user may create a new point or delete an existing point.
- The *View All* command button will display a graph (map) of the currently defined prediction points as well as the currently defined mine plan (if any). The *View* command button will just display the currently defined set of prediction points.
- The *Table* command button will load all points in the database in a spreadsheet type of table. This is considered an "advanced editing feature" and can be disabled or enabled through the options form.
- Notes:
  i. The *cancel* command button will be changed to *close* if irreversible changes are made to the database. Such changes generally include editing of more than one point.
  ii. The *Table* command button should be used by experienced users only, since changes may inadvertetly affect a range of points.
  iii. The insert/append option button determines the location of a new point within the database. Insert locates the new point before the current point, while append adds the point at the end of the list.

6. ***Prediction point data - Grid Points***

- In this input form the user can specify or modify the geometry of Grid

Points. A grid point set may consist of any number of points in a window. This window is defined by minima and maxima in the X- and Y- directions as well as the cell size in each direction.

- Warning: The grid can only be oriented parallel to the current coordinate system. If the grid needs to be oriented at an angle to the current coordinate system, the grid points should be generated by a different tool and imported as scattered points into the Influence Function module.
- The user has two options regarding grid elevations.
  - i. to consider a flat surface and specify a uniform elevation for all points, and
  - ii. to consider each point on an individual basis and specify individual point elevations.
- For individual data points, the individual point elevations database should be initialized using the *Initialize* command button and then the individual point elevations can be entered/modified using the *Table* command button. The *Table* command button will load all points in the database in a spreadsheet type of table. This is considered an "advanced editing feature" and can be disabled or enabled through the options form.
- The *Reset* command button can be used to return to the uniform elevation status. The *Generate* command button can be used to access the generate elevations form where elevations can be generated for any plane in 3-D space.
- The *View All* command button will display a graph of the currently defined prediction points as well as the currently defined mine plan (if any). The *View* command button will display a graph (map) of the currently defined set of prediction points.
- <u>Notes:</u>
  - i. The *cancel* command button will be changed to *close* if irreversible changes are made to the database. Such changes generally include generation of grid elevations, resetting grid point elevations, etc.
  - ii. In this form, the user can not disable any point or group of points.
  - iii. The *Table* command button should be used by experienced users only, since changes may inadvertetly affect a range of points.

7. ***Generate Grid Elevations***

- In this input form the user can specify the necessary geometric data (i.e. the coordinates of a *base point* and the plane direction and dip of the plane through that point) for calculating grid point elevations.
- The *generate* command button should be used to complete the calculations and store all calculated elevations in the point data base.
- <u>Notes:</u>
  - i. Calculations do not affect the coordinates of the grid points.
  - ii. Data entered in this form are preserved and stored as part of the prediction point information.
  - iii. The user may use the "Table" button of the Grid Points form to further edit generated values.

8. ***Spreadsheet Data Editing***

- This grid editor allows the user to edit tabulated data in a spreadsheet manner. The grid editor allows functions such as zooming, cut and paste, as well as option regarding input (multiple or single cell input, etc.). The user will be prompted to confirm saving any changes before returning to the calling form (i.e. definition of a polygonal or rectangular mine plan or of scattered or grid points).
- This is considered an advanced editing feature.
- Grid editing options can be set through the Grid Options menu item and include:
  - i. <u>Select Options:</u> The user can select to mark cells (free), rows or columns.
  - ii. <u>Fill Options:</u> The user can select to fill a single cell or range of cells.
  - iii. <u>Merge Options:</u> The grid tool can automatically merge columns or rows of equal values so that the user can easily visualize grouped entries. Allowed settings are "no merge", "free merge", "restrict row", "restrict column".
  - iv. <u>Insert Options:</u> When inserting a row or column, the new column can be blank or a copy of the current row or column.
  - v. <u>Paste Options:</u> The user can select to paste the selected range or the clipped range (if the selected area is different than the clipped area).
  - vi. <u>Initial Zoom Setting:</u> The initial zoom setting affects the size of the characters in the spreadsheet (grid) editor.
  - vii. <u>Grid Lines:</u> The user can enable or disable the appearance of grid lines.
  - viii. <u>Full View:</u> The user can force the grid editor to occupy the whole computer screen.
  - ix. <u>Maximize Grid Window:</u> The user can eliminate the controls toolbar from the grid editor to allow for more editing space.
  - x. <u>Show Cell Coordinates:</u> The user can enable display of cell coordinates (Coordinate 1,1 is at the top left corner).

9. ***Estimate Edge Effect***

- This form is used to help the user determine the optimum edge effect parameter for use in the specific project. The edge effect is a function of the width-to-depth ratio for each panel and can be estimated in this form. To calculate the edge effect, enter the panel width and overburden depth in the form and click on the *Calculate* command button.

A1.2.3 The Calculate Menu

Use the Calculate menu option to access various data output options and to invoke the solution and calibration routines:

1. ***Calculate Deformations***

- This form is used to define a number of output options for use by the solution module of the Influence Function Method Program. These options include:

i. <u>File Prefix Code:</u> The user should specify up to a 6 character code which will be used as a prefix to the resulting deformation files (if any). For example, if the prefix is "test" then the subsidence file for scattered points will be testSU.DAT. The default prefix is the first 6 characters of the filename.

ii. <u>Output Path:</u> The user can specify the output path for the result files (e.g. deformation files and/or report file). The default path is the current path.

iii. <u>Deformation Indices:</u> The user can specify which deformation indices should be calculated for each project. Available options are:
   (1) Calculate Subsidence
   (2) Calculate Slope
   (3) Calculate Horizontal Displacement
   (4) Calculate Curvature
   (5) Calculate Horizontal Strain
   (6) Calculate Ground Strain
   (7) Calculate Axial Strain (for scattered data sets only, and when in sequence -- the program does not check for the correct point sequence)

iv. Also the user can enable one or all following options:
   (1) <u>Generate Report File:</u> This option will generate a report file (ASCII) which can be either printed or imported into any word-processing package.
   (2) <u>Generate Deformation Files:</u> This option will generate individual deformation files to be used for graphing through the Graphing Module.
   (3) <u>Generate Grid Elevation File:</u> This option will generate a grid will all elevation data used in the calculations. This option is only valid for prediction points on the grid. The resulting file can be used in the graphing module to plot elevation cross-sections.

v. <u>Output Format:</u> The user can specify whether output should be in a grid format (i.e. Surfer or SDPS or SurvCADD) or as XYZ files. Note that the grid option is only available when prediction points are initially specified on a grid. Additionally, it should be noted that the Surfer grid option refers to the Surfer DOS version.

vi. <u>XYZ Format Options:</u> If XYZ Data is selected in the Output Format Options, then the use can select whether to include a header in the XYZ files as well as the number of decimals printed for each point in the XYZ file.

vii. <u>Report Options:</u> If a report is selected, then the options to include the input data and/or paginate the report can be selected.

viii. <u>Check Panel Orientation:</u> When this option is enabled, the program will check the orientation of the panels (for polygonal panels only).

This option may be disabled after a mine plan is checked thoroughly, in order to speed up calculations.

ix. Calculate: This function is used to invoke the solution module. When calculations are completed in the solution module, control returns to the main program.

x. Notes:

(1) All of the above information is saved in the project file.

2. ***Calibrate Influence Function***

- This function allows the user to select the range of the parameters used in the calibration analysis of the problem. Calibration can only be performed on polygonal panels with scattered prediction points. Also, the measured subsidence value should be entered in the appropriate field of the prediction point set. Once input to this form is modified, the project is automatically saved before commencing calculations.
- This form is used to define a range for the parameters used in the calibration process of the Influence Function Method Program. These parameters include:

i. Minimum, maximum and step factor for the tangent of the influence angle: The solution procedure with iterate from the minimum to the maximum value using the step provided and will determine which option produces the least total error between the measured and predicted (calculated) values

ii. Minimum, maximum and step factor for the supercritical subsidence factor for each point in the file: The solution procedure will iterate from the minimum to the maximum value using the step provided and will determine which option produces the least total error between the measured and predicted (calculated) values.

iii. Subsidence Factor Options: The user can select how the program will handle modification of the subsidence factor during its iterative process.

iv. Check Panel Orientation: When this option is enabled, the program will check the orientation of the panels (for polygonal panels only). This option may be disabled after a mine plan is checked thoroughly, in order to speed up calculations.

v. Minimum, maximum and step factor for the edge effect for each side of the polygonal mine plans: The solution procedure with iterate from the minimum to the maximum value using the step provided and will determine which option produces the least total error between the measured and predicted (calculated) values.

vi. Calculate: This function is used to invoke the solution module with the option to perform parametric analysis in the range specified previously. When calculations are completed in the solution module, control returns to the main program.

3. ***Subsidence Development Curve***

- This function allows the user to select the range of the parameters used in the dynamic analysis of the problem. Currently dynamic analysis can only be performed on rectangular panels with any type of points. Once input to this form is modified, the project is automatically saved before commencing calculations.

A1.2.4 The Utilities Menu

Utility menu operations are similar to those presented in section A1.1.3. The options menu item is explained below:

1. ***Options***
   - This form is used to define a number of default parameters and options pertaining specifically to the Influence Function Module. These options include:
     i. Filename Extensions: The default file extensions used in the influence function program can be set in the corresponding entries in this frame. These extensions are used when individual mine plan or prediction point files are specified.
     ii. Project Options
        (1) Default Mine Plan Type: Use this option to specify the default mine plan type for a new project.
        (2) Default Surface Points Type: Use this option to specify the default type of surface points for a new project.
        (3) Default Subsidence Parameters: Use this option to specify the default values for the tangent of the influence angle, the strain coefficient and the percent hardrock.
     iii. Advanced Options: Enable or disable these options to enable or disable the corresponding advanced features of the program. Currently such features include:
        (1) Enable Speadsheet Data Editing: Use this option to enable table or spreadsheet editing of data files (where appropriate).
        (2) Calibration Feature: Use this option to enable the calibration option of the Influence Function Method.
        (3) Update Project ID: Use this option to enable modifying the ProjectID in the output options form when saving using the saveas function.
        (4) Enable Advance Vertex Editing:Use this option to enable editing of vertices for the Polygonal Mine Plans.
        (5) Enable Dynamic Analysis Feature: Use this option to enable the dynamic analysis feature.
        (6) Default Graph Index for Dynamic Analysis: Use this option to select the default graph index to be displayed when graphing the results from a dynamic analysis.
     iv. Miscellaneous Options
        (1) User External Viewer to Display Results: Use this option to enable viewing of result files using an external ASCII viewer.
        (2) Print Module Version Information: Use this option to enable printing the module current version information on all output

generated by this program.

(3) Default Solution Resolution Parameter: This parameter applies to the solution procedure for the polygonal mine plans. A higher value provides more accuracy but takes more time. The default value is 50.

(4) Confirmation Messages: These options enable a number of confirmation and/or warning messages in the program.

v. Panel Options

(1) Default Panel Options: These options set the default environment for editing mine plan panels.

(2) Polygonal Panel Warning Options: These options enable a number of warning messages during editing of mine plan panels.

A1.3 The Pillar Stability Module

A1.3.1 The File Menu

File menu operations are similar to those presented in section A1.1.1.

A1.3.2 The Edit Menu

Use the Edit menu option to access various data input, data editing operations and data graphing operations such as:

1. ***Project Description***
   - This is an arbitrary 300 character description of the model being generated. It is a good idea to make this a fairly detailed description of the specifics of the input file. This text may be a single line of characters or may contain "carriage return characters".
   - The user can also set the type of units that will be used in the current project. The program is designed to use two different sets of units: ft and m.
2. ***Pillar Stability Parameters***
   - The following parameters are necessary for the calculations:
     - i. <u>Pillar geometry data:</u> which includes:
       - (1) the average unit weight of the overburden
       - (2) the average overburden depth
       - (3) the pillar width
       - (4) the pillar length
       - (5) the pillar height
       - (6) the opening width
       - (7) the average extraction ratio
     - ii. <u>Pillar strength data:</u> which includes:
       - (1) the in-situ uniaxial compressive strength of coal (or laboratory values or the coal strength factor)
       - (2) the in-situ uniaxial compressive strength of coal is the most appropriate value to enter here. If the above value is not readily known, then it can be calculated using two methods: (a) by using the laboratory value for the uniaxial compressive strength of coal and the sample specimen size and (b) by using the coal strength factor for the particular seam.
     - iii. <u>Output options:</u> The user may specify the following output options:
       - (1) <u>Results mode:</u> This option allows the user to select whether to view the results in the form of graph (Display Graph) or in the form of a table (Display Table). The default results mode option can be set through the Pillar Stability Analysis Module Options.
       - (2) <u>Graph selection:</u> Use this option to select the parametric graph to be displayed if the *Display Graph* option is enabled. The default graph selection option can be set through the

Pillar Stability Analysis Module Options. The following options are available (SF stands for Safety Factor):

(a) SF vs Pillar Width
(b) SF vs Pillar Height
(c) SF vs Overburden Depth
(d) SF vs Extraction Ratio

(3) Table output:Use this option to select whether to include header information in the table output as well as, whether to include the "depth of crushing" calculations.

- Notes:
  - i. The program will automatically choose the least of the pillar dimensions for the strength calculations.
  - ii. The program will automatically calculate and display on the input form the extraction ratio as calculated from the tributary area of the pillar (when all appropriate pillar dimensions are entered). The value used for calculations, however, is the average extraction ratio entered by the user.

3. ***Protection Area Parameters***

- Use this option to enter surface structure data for a new case study, or to edit data for a case study loaded from disk. The data will be used to calculate the dimensions of the protection area at seam level. Also, the total area of coal in the protection area underneath the structure is calculated. Required input includes:
  - i. the average overburden depth,
  - ii. structure dimensions,
  - iii. the minimum and maximum angle of protection (measured from the vertical),
  - iv. the horizontal structure dimension adjustment, and
  - v. the maximum extraction ratio for the proposed protection area.

A1.3.3 The Output Menu

Use the Output menu option to access various output options such as:

1. ***Safety Factors***

- Standard Geometry
  - i. Use this option to obtain the Safety Factors for standard mine geometry and for all pillar stability formulations
- Result Window:
  - i. The user may navigate through the result window by clicking on the Previous Page or Next Page buttons.
  - ii. Each and all of these output pages may be printed to any Windows printer.
  - iii. Each and all of these output pages may be copied to the Windows clipboard for use in other applications.
- Advanced Geometry
  - i. Use this option to obtain the Safety Factors for standard mine geometry and for all pillar stability formulations

- See Result Window above

2. ***Protection Area***

Using this option, one can obtain the results for the protection area calculations. See also “Result Window” above.

3. ***Graph***

Using this option, one can produce a series of parametric graphs, such as SF vs height, SF vs Pillar Width, SF vs Pillar Height, etc.

- Pillar Stability Graph Options: The user can set the basic graph formatting parameters such as:
  - i. The graph title: The graph title is a text string placed over the graph. The default graph title is: "Pillar Stability Analysis".
  - ii. The graph x-axis titles: The x-axis titles selection includes four text fields, one for each type of parametric graph that can be specified. These four fields correspond to the x-axis titles of the following graph types:
    - (1) SF vs. Pillar Width
    - (2) SF vs. Pillar Height
    - (3) SF vs. Overburden Depth
    - (4) SF vs. Extraction Ratio

    The default text strings for each one of these cases (placed below the x-axis of each graph) are:

    Pillar Width (units)
    Pillar Height (units)
    Overburden Depth (units)
    Extraction Ratio (%)

    Note that only then title pertaining to the currently selected graph can be edited.
  - iii. The graph y-axis title: The y-axis title is a text string placed to the left of the y-axis of the graph. The default y-axis title is "Safety Factor".
  - iv. The remaining options are explained in section A1.1.2.

A1.3.4 The Utilities Menu

Utility menu operations are similar to those presented in section A1.1.3. The options menu item is explained below:

1. ***Options***

- This form is used to define a number of default parameters and options pertaining specifically to the Pillar Stability Analysis Module:
  - i. General Options
    - (1) Load Input Screen on File Open: This option controls whether the main (or advanced) parameter input screen will automatically be displayed when the user selects File -Open (filename) or File - New.
    - (2) Plot Entry Dimensioning: This option will enable plotting of entry dimensioning when the mine plan input data or results are plotted on the screen.

(3) Plot Crosscut Dimensioning: This option will enable plotting of crosscut dimensioning when the mine plan input data or results are plotted on the screen.

(4) View Project File in Child Window: When this option is enabled, the "view" command button in the pillar parameter screen will launch a child window with the plan view plot of the mine works. Otherwise, a plot will be generated in the small window on the pillar parameter form.

(5) Share Geometry Data in all formulations: If this option is enabled, common geometry data (i.e. overburden depth, seam thickness, etc., are shared between the active formulations (i.e. pillar stability, protection area, etc.) in the module.

(6) Share Strength Data in all formulations: If this option is enabled, common strength data (i.e. pillar strength, etc.), are shared between the active formulations (i.e. pillar stability, protection area, etc.) in the module.

(7) Print Module Version Information: This option will enable printing of a module header when a print function is executed.

ii. Default Settings

(1) Calculate Depth of Pillar Crushing: This option will enable the calculation of the depth for pillar crushing which will be reported in the tabulated output of the pillar stability module.

(2) Default Protection Angle: This value will be the default setting for the minimum protection angle in the protection angle input parameter form. The maximum protection angle is set 20 deg more than the minimum.

(3) Default Protection Angle Step: This value will be the default setting for the protection angle step in the protection angle input parameter form.

(4) Minimum value for Parametric Analysis (%): This percentile value determines the lower limit of the x-axis in all parametric graphs.

(5) Maximum value for Parametric Analysis (%): This percentile value determines the upper limit of the x-axis in all parametric graphs.

iii. Unit Settings

(1) Output Units (Strength): The user can select the type of strength units (if English units are selected) that will be displayed in the output screen.

(2) Output Units (Strength Gradient): The user can select the type of strength gradient units (if English units are selected) that will be displayed in the output screen.

A1.4 The ALPS Module

A1.4.1 The File Menu
File menu operations are similar to those presented in section A1.1.1.

A1.4.2 The Edit Menu
Use the Edit menu option to access various data input, data editing operations and data graphing operations such as:

1. ***Project Description***
   - This is an arbitrary 300 character description of the model being generated. It is a good idea to make this a fairly detailed description of the specifics of the input file. This text may be a single line of characters or may contain "carriage return characters".
   - The user can also set the type of units that will be used in the current project. The program is designed to use two different sets of units: ft and m.
2. ***Project Parameters***
   - The following parameters are necessary for the calculations:
   - <u>Parameters of Forward Model:</u>
     i. <u>Entry Height:</u> The mining height or coal seam thickness (in feet or meters).
     ii. <u>Depth of Cover:</u> The depth of cover or overburden thickness over the pillar system (in feet or meters). In regions of sharp topographic variation it may be too conservative to use the maximum cover if it is only present over a small portion of the panel, but the average depth might underestimate the load over the deeper sections. Some engineering judgement should be exercised, but in general an appropriate value of the depth of cover for ALPS is a high average expressed as: H = (Havg + Hmax)/2
     iii. <u>Panel Width:</u> The width of the longwall panel (or face length) (in feet or meters).
     iv. <u>Entry Width:</u> The width of the entries. Crosscuts are assumed to be the same width as the entries (in feet or meters).
     v. <u>Crosscut Spacing:</u> The center-to-center crosscut spacing. Crosscuts are assumed to be driven perpendicular to the entries (in feet or meters).
     vi. <u>Number of Entries:</u> The number of entries to be modelled.
     vii. <u>Entry Spacings:</u> The center-to-center spacings (in feet or meters).
     viii. <u>In Situ Coal Strength:</u> The in situ coal strength (in psi or MPa). The default value is 900 psi or 6.2 MPa.
     ix. <u>Abutment Angle:</u> The abutment angle in degrees. The default value is 21 degrees.
     x. <u>Unit weight of the Overburden:</u> The unit weight of the overburden (in pcf or kN/m^3). The default value is 162 pcf or 25.47 kN/m^3

- Notes:
  - i. Users generally will not need to adjust the abutment angle, which determines the magnitude of the abutment loads, and the in situ coal strength, which is used in the calculation of the pillar load-bearing capacity. The research that went into the development of ALPS indicated that these two variables should be set at 21 degrees and 900 psi, respectively (Mark, 1992). In particular, research has found that there is no correlation between the performance of longwall pillars and the uniaxial compressive strength of coal specimens (Mark and Barton, 1996; Mark 1999).
- Parameters of Reverse Model:
  - i. User and Suggested Safety factors: The user may enter a set of stability factors to be used in the calculation of pillar widths for each pillar configuration of the sizing mode. Alternatively, the user may specify CMRR values and the program will display suggested stability factors for pillar sizing.
  - ii. CMRR: The CMRR value is used for calculating the suggested stability factors. If the "Use CMRR suggested factors" check box is enabled, then the solution routines will ignore the user stability factors and utilize the CMRR suggested factors. The formulas used to suggest the SF are defined in the Coal Mine Roof Rating section.
  - iii. Pillar Configuration: Sizing can be accomplished using three pillar configuration options:
    - (1) Equal Sized Pillars
    - (2) Yield-Abutment Pillars
    - (3) Yield-Abutment-Yield Pillars
    - (4) Yield Pillar Width
- Notes:
  - i. In the case of a pillar configuration of Yield-Abutment Pillars or Yield-Abutment-Yield Pillars, the user should enter the yield pillar width. The yield pillar width is solid coal, not center-to-center!

A1.4.3 The Output Menu

Use the Output menu option to access various output options such as:

1. ***Stability Factors***
   - Standard Geometry
     - i. Use this option to obtain the ALPS stability factors for both the ALPS (Classic) and ALPS (Revised) formulations under standard geometry conditions (crosscuts are at 90 degrees to the entries). The ALPS (Classic) calculates the unit strength of the pillars using Bieniawski's empirical pillar strength formula, while ALPS (Revised) calculates the unit strength of the pillars using Bieniawski's revised empirical pillar strength formula.
   - Result Window:
     - i. The user may navigate through the result window by clicking on the

Previous Page or Next Page buttons.

ii. Each and all of these output pages may be printed to any Windows printer.

iii. Each and all of these output pages may be copied to the Windows clipboard for use in other applications.

- Advanced Geometry

  i. Use this option to obtain the ALPS stability factors for both the ALPS (Classic) and ALPS (Revised) formulations under advanced geometry conditions (crosscuts are at less than 90 degrees to the entries). The ALPS (Classic) calculates the unit strength of the pillars using Bieniawski's empirical pillar strength formula, while ALPS (Revised) calculates the unit strength of the pillars using Bieniawski's revised empirical pillar strength formula.

- See Result Window above

2. ***Size Pillars***
   - Use this option to size the pillars (see also parameters of the reverse model)
3. ***Graph [ALPS Classic]***
   - Using this option, one can produce a series of parametric graphs, such as SF vs height, SF vs Depth of Cover, SF vs Panel Width, etc., for the ALPS (Classic) formulation.
4. ***Graph [ALPS (R)]***
   - Using this option, one can produce a series of parametric graphs, such as SF vs height, SF vs Depth of Cover, SF vs Panel Width, etc., for the ALPS (Revised) formulation.

A1.4.4 The Utilities Menu

Utility menu operations are similar to those presented in section A1.1.3. The options menu item is explained below:

1. ***Options***
   - This form is used to define a number of default parameters and options pertaining specifically to the ALPS Module. These options include:

     i. Load Input Screen on File Open: This option will load the main parameter input screen when the user selects File -Open (filename) or File - New.

     ii. View Project File in Child Window: When this option is enabled, the "view" command button in the pillar parameter screen will launch a child window with the plan view plot of the mine works. Otherwise, a plot will be generated in the small window on the pillar parameter form.

     iii. Print Module Version Information: This option will enable printing of a module header when a print function is executed.

     iv. Plot Entry Dimensioning: This option will enable plotting of entry dimensioning when the mine plan input data or results are plotted on the screen.

     v. Plot Crosscut Dimensioning: This option will enable plotting of crosscut dimensioning when the mine plan input data or results are plotted on the screen.

vi. Output Units (Strength): The user can select the type of strength units (if English units are selected) that will be displayed in the ALPS output screen.

vii. Output Units (Strength Gradient): The user can select the type of strength gradient units (if English units are selected) that will be displayed in the ALPS output screen.

A1.5 The ARMPS Module

A1.5.1 The File Menu

File menu operations are similar to those presented in section A1.1.1.

A1.5.2 The Edit Menu

Use the Edit menu option to access various data input, data editing operations and data graphing operations such as:

1. ***Project Description***
   - This is an arbitrary 300 character description of the model being generated. It is a good idea to make this a fairly detailed description of the specifics of the input file. This text may be a single line of characters or may contain "carriage return characters".
   - The user can also set the type of units that will be used in the current project. The program is designed to use two different sets of units: ft and m.
2. ***Project Parameters***
   - The following parameters are necessary for the calculations:
     - i. Entry Height: The mining height or coal seam thickness (in feet or meters).
     - ii. Depth of Cover: The depth of cover or overburden thickness over the pillar system (in feet or meters). In regions of sharp topographic variation it may be too conservative to use the maximum cover if it is only present over a small portion of the panel, but the average depth might underestimate the load over the deeper sections. Some engineering judgement should be exercised, but in general an appropriate value of the depth of cover for ALPS is a high average expressed as: H = (Havg + Hmax)/2
     - iii. Crosscut Angle: The angle between the longitudinal axis of an entry and the crosscut direction (degrees), where 90 is perpendicular to the entry.
     - iv. Entry Width: The width of the entries. Crosscuts are assumed to be the same width as the entries (in feet or meters).
     - v. Crosscut Spacing: The center-to-center crosscut spacing. Crosscuts are assumed to be driven perpendicular to the entries (in feet or meters).
     - vi. Number of Entries: The number of entries to be modelled.
     - vii. Entry Spacings: The center-to-center spacings (in feet or meters).
     - viii. In Situ Coal Strength: The in situ coal strength (in psi or MPa). The default value is 900 psi or 6.2 MPa.
     - ix. Unit weight of the Overburden: The unit weight of the overburden (in pcf or kN/m^3). The default value is 162 pcf or 25.47 kN/m^3.
     - x. Breadth of AMZ: The breadth of the Active Mining Zone (in feet or meters).
     - xi. Type of Loading Condition: There are 5 types of loading conditions

that can be modeled: Development Load, One Active Retreat Section, Active Retreat Section and One Side Gob, Active Retreat Section and Two Sides Gob, and Bleeder. Each option may require a number of parameters such as the Abutment Angle (typically 21 degrees), the extend of the active gob, the width of the barrier pillar on each side and the depth of slab cut in barrier pillar on each side.

- Notes:
  i. Users generally will not need to adjust the breadth of the AMZ zone, since it can be automatically calculated.

A1.5.3 The Output Menu

Use the Output menu option to access various output options such as:

1. ***Stability Factors***
   - Result Window:
     i. The user may navigate through the result window by clicking on the Previous Page or Next Page buttons.
     ii. Each and all of these output pages may be printed to any Windows printer.
     iii. Each and all of these output pages may be copied to the Windows clipboard for use in other applications.
2. ***Graph***
   - Using this option, one can produce a series of parametric graphs, such as SF vs height, SF vs Depth of Cover, SF vs Crosscut Angle, etc.,

A1.5.4 The Utilities Menu

Utility menu operations are similar to those presented in section A1.1.3. The options menu item is explained below:

1. ***Options***
   - This form is used to define a number of default parameters and options pertaining specifically to the ARMPS Module. These options include:
     i. Edit Options
        (1) Load Input Screen on File Open: This option will load the main parameter input screen when the user selects File - Open (filename) or File - New.
        (2) View Project File in Child Window: When this option is enabled, the "view" command button in the pillar parameter screen will launch a child window with the plan view plot of the mine works. Otherwise, a plot will be generated in the small window on the pillar parameter form.
     ii. Print/Plot Options
        (1) Print Module Version Information: This option will enable printing of a module header when a print function is executed.
        (2) Plot Entry Dimensioning: This option will enable plotting of entry dimensioning when the mine plan input data or results

are plotted on the screen.

(3) Plot Crosscut Dimensioning: This option will enable plotting of crosscut dimensioning when the mine plan input data or results are plotted on the screen.

(4) Plot Extend of Gob: This option will enable plotting of the extend of gob when the mine plan input data or results are plotted on the screen.

iii. Output ptionsOptions

(1) Output Units (Strength): The user can select the type of strength units (if English units are selected) that will be displayed in the ALPS output screen.

(2) Output Units (Strength Gradient): The user can select the type of strength gradient units (if English units are selected) that will be displayed in the ALPS output screen.

(3) Minimum value for Parametric Analysis (%): This percentile value determines the lower limit of the x-axis in all parametric graphs.

(4) Maximum value for Parametric Analysis (%): This percentile value determines the upper limit of the x-axis in all parametric graphs.

A1.6 The Graph Module

A1.6.1 The File Menu

Use the File menu option to access various file management operations such as:

1. Open Project
   - Use the Open Project option to load a "solved" influence function project file. The default extension for these project files is "*.GFI" and not "*.PRJ" which is the default extension for influence function project files. A project file provides information regarding the deformation indices calculated by the influence function and the file specifications for each deformation index file.
2. Load Graph
   - Use the Load Graph option to load a saved graph file (see the Save Graph option below). This option is useful when reviewing a graph saved through one of the graph forms.
3. Browse
   - See discussion in A1.1.1.
4. Exit
   - See discussion in A1.1.1.

A1.5.2 The 2-D Menu

1. Use the 2-D menu option to access the two-dimensional plotting options:
   - <u>The cross-sectional plots:</u> In this form the user can select the index to be plotted as well as the formatting parameters for this index. The basic formatting parameters are as follows:
     - i. <u>The graph title:</u> The graph title is a text string placed over the graph.
     - ii. <u>The graph x-axis title:</u> The x-axis title is a text string placed below the x-axis of the graph.
     - iii. <u>The graph y-axis title:</u> The y-axis title is a text string placed to the left of the y-axis of the graph.
     - iv. <u>The grid style:</u> Four grid styles are available: Horizontal lines, vertical lines, horizontal and vertical lines, no grid lines.
     - v. <u>The graph style:</u> Three graph styles are available: lines, symbols, lines and symbols.
     - vi. <u>The maximum number of curves:</u> The user can specify the maximum number of curves that can be overlaid on the graph. When this number is exceeded the user will be prompted to clear the graph before proceeding.
     - vii. <u>The curve legend:</u> This option enables or disables the legend box in the graph.
     - viii. <u>The symbol size:</u> With this scroll box the user can set the size of the symbols used by the graph object. The scroll box is enabled only for a graph type of "symbols" or "lines and symbols".
     - ix. <u>The Default parameter options:</u> There are two default parameter

options: a) to set the default parameters (i.e. graph title, x-axis title, etc.) every time the graph options form is invoked, and b) to set the format parameters to used in the previous graphing session. These values are saved in the corresponding module.INI file. Note that when the default parameter set is enabled, changes to the form components are disabled.

- Notes:
  - i. Depending on the type of surface points available in the current project, there are two types of cross-sections that can be created:
    - (1) Cross-sections plotted from a grid file. In this case, multiple cross-sections can be overlaid and the user should select the orientation and intercept of the cross-section.
    - (2) Cross-sections plotted from a set of scattered points. In this case, cross-sections can be defined as X-projections, Y-projections or Axial projections.
- <u>the vector plots:</u> In this form the user can select the index to be plotted as well as the formatting parameters for this index. The basic formatting parameters are as follows:
  - i. <u>The graph title:</u> The graph title is a text string placed over the graph.
  - ii. <u>The default parameter options:</u> There are two default parameter options: a) to set the default parameters (i.e. graph title, x-axis title, etc.) every time the graph options form is invoked, and b) to set the format parameters to used in the previous graphing session. These values are saved in the corresponding module.INI file. Note that when the default parameter set is enabled, changes to the form components are disabled.

A1.6.3 The 3-D Menu

1. Use the 2-D menu option to access the two-dimensional plotting options:
   - In this form the user can select the index to be plotted as well as the formatting parameters for this index. The basic formatting parameters are as follows:
     - i. <u>The graph title:</u> The graph title is a text string placed over the graph.
     - ii. <u>The default parameter options:</u> There are two default parameter options: a) to set the default parameters (i.e. graph title, x-axis title, etc.) every time the graph options form is invoked, and b) to set the format parameters to used in the previous graphing session. These values are saved in the corresponding module.INI file. Note that when the default parameter set is enabled, changes to the form components are disabled.
   - <u>Notes:</u>
     - i. The user can set the rotation and elevation of the 3-D image from the Graph Form.

A1.6.4 The Utilities Menu

Utility menu operations are similar to those presented in section A1.1.3. The options menu item is explained below:

1. ***Options***
   - This form is used to define a number of default parameters and options pertaining specifically to the data export functions of the Graphing Module. These options include:
     i. <u>Format:</u> Use this option to specify whether the exported data will be in free format or fixed format. See details on fixed format below.
     ii. <u>Delimiter:</u> Use this option to specify the default delimiter character between data columns. The delimiter can either be the SPACE character or the TAB character.
     iii. <u>Fixed format options:</u> Use this option to the fixed format configuration. The user needs to specify the total width of each data column (in characters), the number of digits used for the integer portion of the number as well as the number of decimal digits. Allowing for one character position for the sign of the number and one position for the decimal point, the following relationship should always be true:
     NoIntegerDigits + NoDecimalDigits + 2 < ColumnWidth
     The default parameters are:
     (1) NoIntegerDigits = 6
     (2) NoDecimalDigits =3
     (3) ColumnWidth = 12

Appendix 2: The Initialization File

Each SDPS module creates its own initialization (*.INI) file. This initialization file is *automatically* created by all SDPS modules the first time they are executed. They should reside in the home directory of the SDPS programs, i.e. \Program Files\SDPS for Windows\

- The profile function method module creates and uses the PROF.INI file.
- The influence function method module creates and uses the INFL.INI file.
- The pillar stability analysis module creates and uses the PILL.INI file.
- The graphing module creates and uses the GRAF.INI file.

Sample entries are shown below (the sequence and parameter values may be different in the actual file):

```
[Settings]
DefaultUnits=0
DisplayActionWin=1
MaxDisplaySize=300
KeepFileNames=1
ShowDisclaim=0
DataPath=C:\SDPS\
FileExtension=PRF

[FileMenu]
MaxLastFiles=1
LastFile1=C:\SDPS\TEST.PRF

[TextBrowse]
BrowseFontName=Courier New
BrowseFontSize=10
BrowseFontBold=0
BrowseFontItalic=0
```

Notes:

- If this initialization file is deleted, it will be automatically reconstructed the next time the program is executed, but the various settings will default to their original values.

Appendix 3: Setting up Projects for the Influence Function Method

A3.1 Common Questions

Question: In what context are the terms panel, pillar and parcel used in the mineplan definition?
The term **panel** defines the boundaries of any single extraction area (extraction boundaries).
The term **pillar** defines the boundaries of any single pillar. Note that pillars can not exist outside extraction boundaries (panels).
The term **parcel** may refer to either a panel entity or a pillar entity.

Question: How can a longwall panel be defined?
A longwall panel can be defined by **one parcel** which will be specified as a **panel**. Everything else around the panel is assumed to be solid material.

Question: How can a room-and-pillar panel be defined?
A room-and-pillar panel should be defined by **more than one parcels.** One parcel should be specified as a panel and will define the boundaries of the room-and-pillar panel itself (extraction boundaries, extraction area) and the remaining parcels should be defined as pillars **within** the extraction area (panel).

Question: The mineplan comprises of multiple longwall panels, room and pillar sections, mains and submains. Should everything be digitized and imported in SDPS?
An efficient way of modeling a complicated mineplan is to identify areas with similar extraction characteristics and digitize those areas only. In this sense, a room-and-pillar section would just be one polygon, a submains section would be another, etc.

Question: The project includes a polygonal mineplan and scattered points. Can grid points be exported?
No. Grid points can only be exported if a grid is used for the prediction points.

Question: In polygonal mineplans, can the program automatically account for the edge effect?
No. The program can only automatically account for the edge effect in the case of the rectangular mineplan.

A3.2 Examples of Erroneous Panel Definitions for the Influence Function Method Formulation

Figure A3.2.1 presents a digitized mineplan, which includes 5 longwall sections, with the appropriate entries around each panel. However, if this plan is used for surface deformation calculations using the SDPS package, the results will be erroneous because there are logical errors in the mine plan description:

- According to the definitions given in Chapter 3, all pillars should be placed inside extraction areas. In this case, 5 extraction areas are defined, one for each longwall panel. However, the pillars are **not** placed inside any extraction area.
- Subsidence calculations for this case will produce negative subsidence in the middle of the panels and **positive** subsidence around the panels over the pillars in the entries.
- One way of producing a mine plan without logical errors would be to create one boundary line around all mining activity and dismiss the individual extraction panels, as shown in Figure A3.2.2.
- A second logical error in this plan can be observed when focusing on the last set of entries (bottom). This detail is shown in Figure A3.2.3. Overlapping pillars can be observed in this case (due to digitization errors). Their influence will be minor in the final result, but it is nevertheless a logical error.

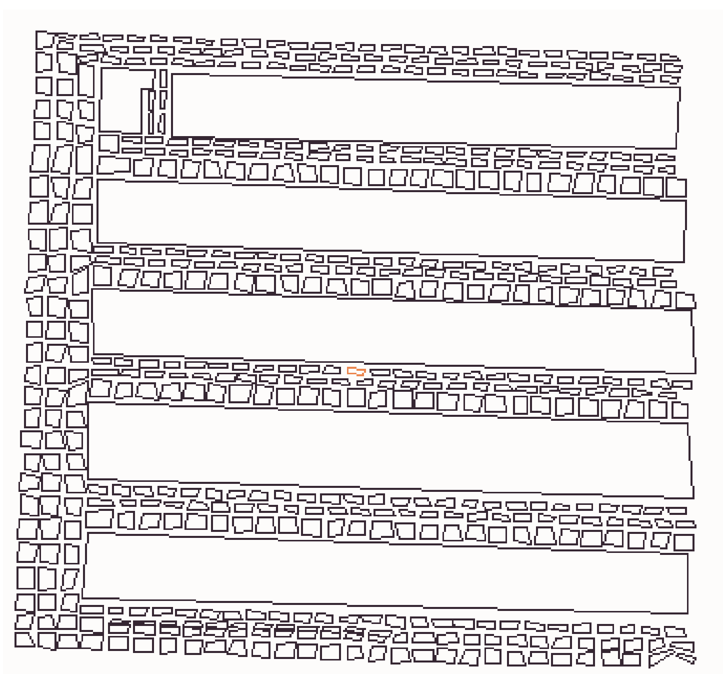

Figure A3.2.1: Example of digitized mineplan with logical errors

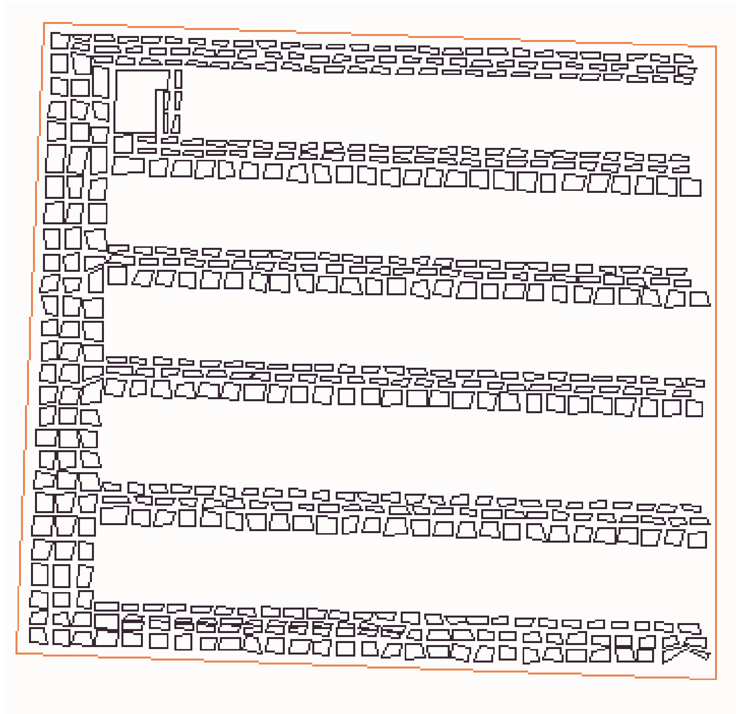

Figure A3.2.2: Corrected mineplan regarding the placement of the pillars withing an extraction area

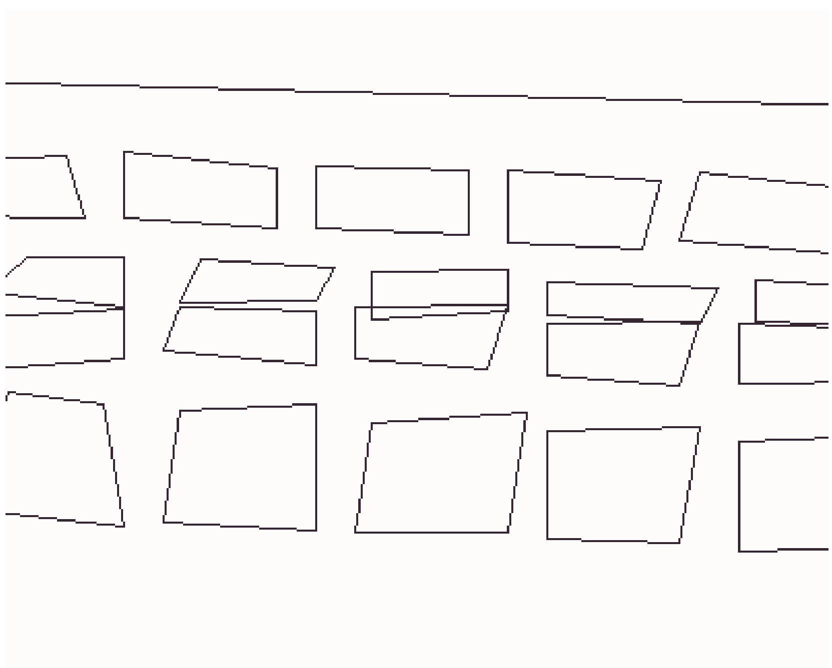

Figure A3.2.3: Detail of bottom entry system: Overlapping pillars

Figure A3.2.4 shows in detail the digitized mineplan of a section of another longwall operation. Here, it appears that each pillared section is enclosed in an extraction area, which conforms to the specifications. However, this is not the most efficient way to do these calculations:

- Creating a large extraction area is much more efficient than small adjacent extraction areas.
- The possibility of creating overlapping extraction areas increases with the number of small adjacent areas used in a project.
- Increased number of areas results in increased solution times.

A3.3 Examples of Simplifying Problem-Solving for the Influence Function Method Formulation

Figure A3.3.1 presents a digitized mineplan, which includes 5 longwall sections, with the appropriate entries around each panel (mains and submains). Although this is a "correct" mineplan in terms of definitions, the calculation of surface deformation will take a long time due to the large number of mineplan points. Figures A3.3.2 and A3.3.3 present an alternative approach to the same problem.

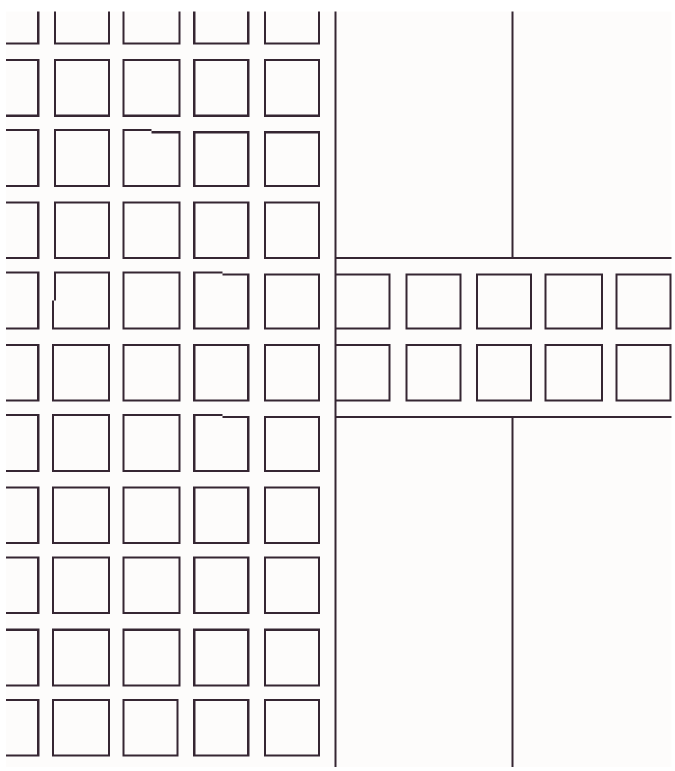

Figure A3.2.4: Detail of longwall operation with multiple adjacent extraction areas

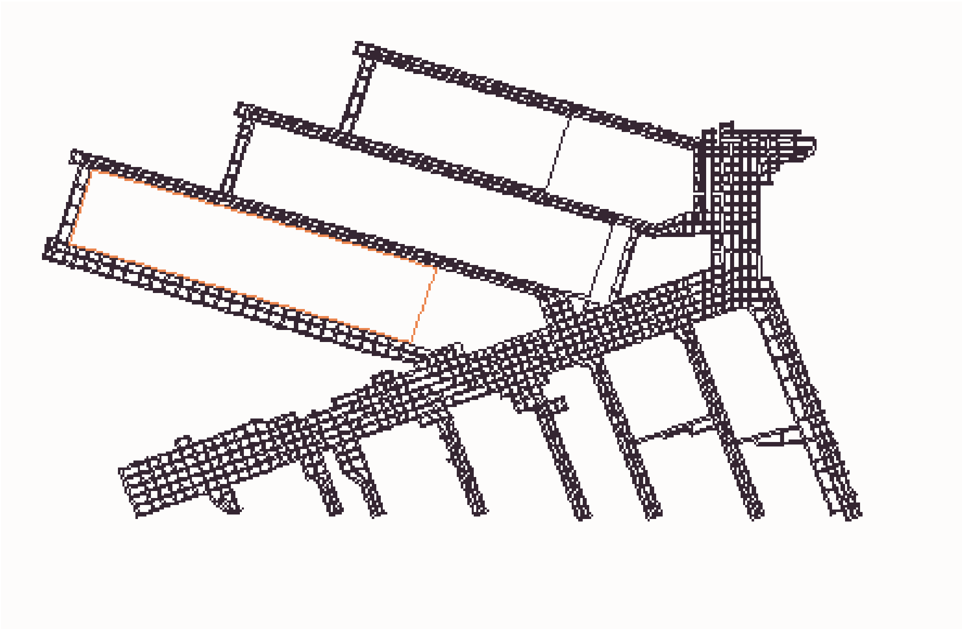

Figure A3.3.1: Digitized mineplan with 5 longwall sections

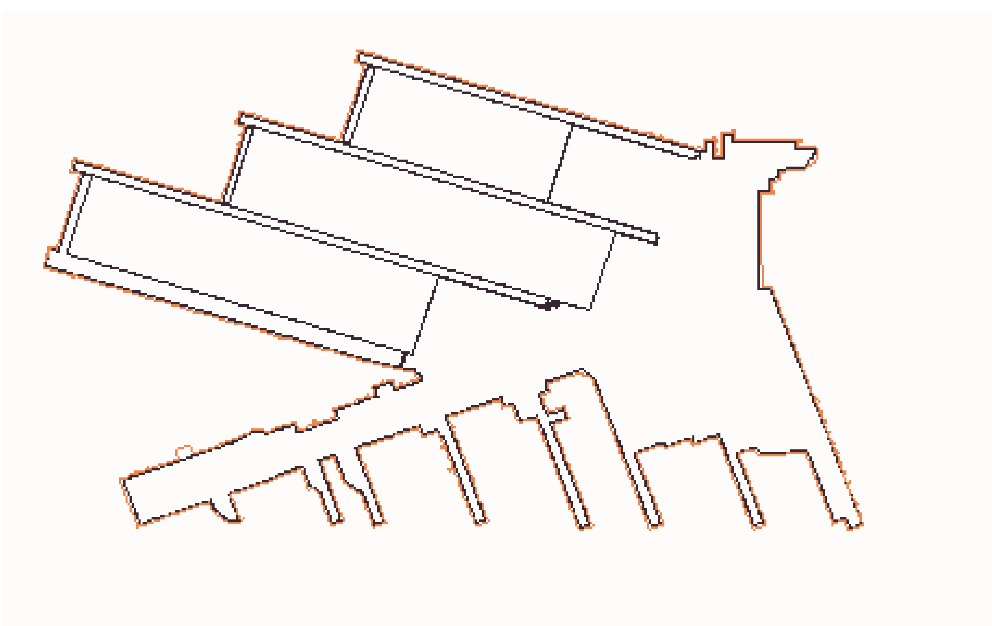

Figure A3.3.2: Simplified mineplan where all the mains and submains sections are considered as one parcel. The two small panels on the right can easily be added to this layout

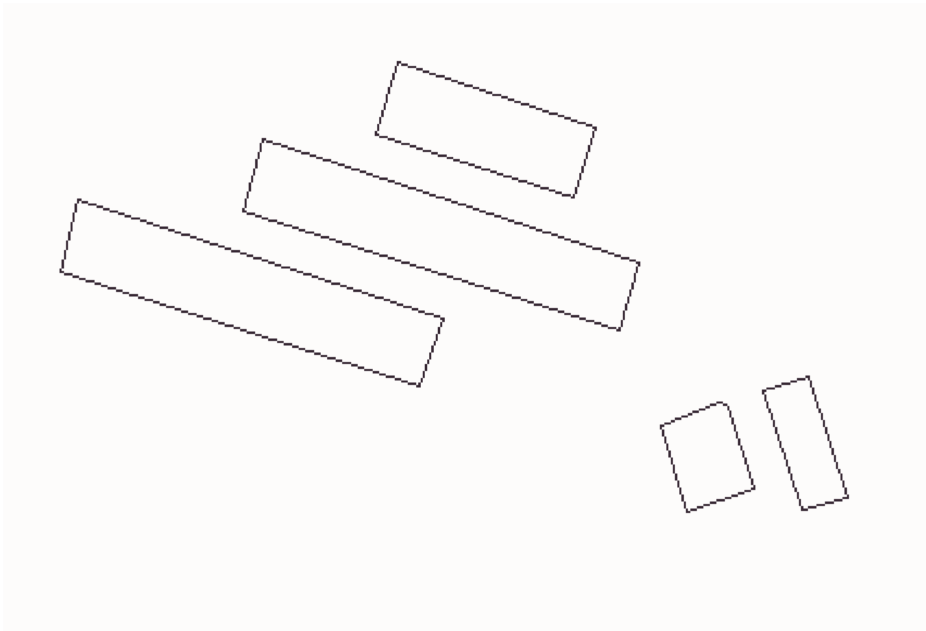

Figure A3.3.3: Very simple mineplan which includes just the extracted areas of the 5 panels.

Appendix 4: Troubleshooting

A4.1 General Problems

Problem: The registration information does not seem to work. The program does not allow saving of the license information.
Make sure that you have submitted the correct license code to the supplier and that you entered the license code correctly. The license code should not contain any letter O; substitute zero (0) instead.

Problem: The software has been registered, it worked for a while and now it comes up with the message “Demo expired” and stops working.
In the original versions of the package, installation or re-installation erased all previous licensing information. However, it kept the date of the first installation as well as a count of the number of function calls during its demo operation. If re-installation occured after 30 days of original installation or after 200 function calls were performed in demo mode, then the “Demo expired” message was triggered. Note that this behavior is not expected **for upgrades** of versions 5.1P and later. If upgrading from a much older version, then this message will appear again. Please obtain a new license code from the supplier.

Problem: Some forms are truncated and may be larger that the current windows screen.
Most of the forms were designed to fit on a screen with a resolution of 640x480. However, some forms, need a screen resolution of 800x600 to display properly. To correct the problem, please set the resolution in the "Settings" section of the "screen properties" option (right click on the windows screen and select properties), to these settings.

Problem: Command button captions, form captions and labels are truncated or wrapped.
The command buttons, forms and labels were designed using the MS San Serif font (size 8). Changing the default settings for the windows desktop and screen may affect the appearance of the forms and labels in SDPS 5.x. To correct the problem, please set the corresponding fonts in the "Appearance" section of the "screen properties" option, to these settings (right click on the windows screen and select Properties).

Problem: When accessing data through the Table mode (spread sheet mode), the decimals seem to disappear.
If the localization settings (regional settings) for your Windows environment is set to allow for xx.xxx,yy instead of xx,xxx.yy then data entry through the Table mode will not work because this feature is not supported by the 3rd party vendor of this object. Please revert to US regional settings.

A4.2 Problems in the Influence Function Module

Problem: Mine plan files digitized in AutoCAD and saved as a DXF file, can not be imported or are not properly imported, to the Influence Function Module.
Make sure that:

- the mineplan layers (PANELS, PILLARS, etc.) are defined properly
- the mineplan elements (entities) are digitized as polylines
- the mineplan entities are **not** defined as blocks
- all mineplan objects are selected when exporting to DXF
- the scaling factors on the input form are reset to 1
- the “append data” option on the input form is disabled

If everything fails, try exporting the mineplan as a DXF file for AutoCAD R12LT (use the options button in the AutoCAD “dxfout” interface).

Problem: The mine plan has been defined and imported without any problems. However, when viewing the mine plan, all parcels are clustered in one dot on the view window.
You may have defined a 0,0 point by accident. The view window tries to fit in all point and the 0,0 point may be grossly out of scale compared to the XY coordinates of your mineplan. To correct the problem:

- find the 0,0 point and delete it

Problem: Prediction point files digitized in AutoCAD and saved as a DXF file, can not be imported or are not properly imported to the Influence Function Module.
Make sure that:

- the prediction point layers (POINTS, etc.) are defined properly
- the elevation values for the points are set to the proper values
- the scaling factors are reset to 1
- the “append data” option on the input form is disabled

If everything fails, try exporting the mineplan as a DXF for AutoCAD R12LT.

Problem: AutoCAD 2000 is installed on the computer. However, no entities can be imported through the import forms.
Make sure that:

- AutoCAD 2000 if functioning properly in stand-alone mode
- mine plan entities (panels or pillars) are defined as light-weight polylines or 3d polylines.
- contours are defined as as light-weight polylines or 3d polylines.

If everything fails, try exporting the mineplan as a DXF file.

Problem: The “Table” command button is disabled in the mineplan and prediction points forms.

Make sure that:

- the advanced editing feature is enabled in the Utilities / Options form.

Problem: The project has been defined and saved without any problems. However, when calculating surface deformations zero values are obtained for one or more deformation indices.

Make sure that:

- prediction points overlap the mine plan (verify by using “View All” in the mineplan editor or in the prediction point editor),
- the elevation difference between mineplan and prediction points is properly set, and it is larger than 0, and
- the seam thickness and subsidence factor values were properly set (for imported or hand-keyed mineplans).

Problem: The project has been defined and saved without any problems. However, when calculating surface deformations, positive values for subsidence are generated.

Make sure that:

- all pillars are surrounded by an extraction boundary (panel),
- there are no pillars that lie outside extraction boundaries, and
- extraction boundaries are defined as panels and **not** as pillars.

Problem: The mineplan has been digitized exactly as provided. However, the program predicts surface deformations over mains and areas with less than 50% extraction.

The method will indeed predict very small surface deformations over areas that should not experience any such deformations. If such deformations are attributed to mains or very low extraction areas, then to eliminate them, do the following:

- digitize such areas as unified solid pillars

with appropriate boundary lines.

Problem: When checking the orientation of the panels, the program identifies parcels that need to be rotated counter-clockwise and rotates them either manually or automatically. Re-running the check routine, the program still identifies parcels that “need” rotation.

Make sure that:

- these parcels are not “zero area” parcels or parcels where the perimeter crosses itself (Figure A.4.1).

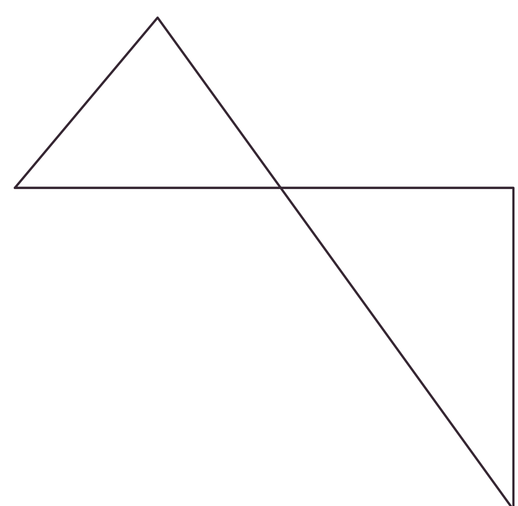

Figure A.4.1: Illegal parcel. Its rotation can not be properly identified

Problem: The “Calibration Influence Function” Option is not enabled.

Make sure that
- the appropriate option is set in the Utilities-Options form.

A4.3 Further Assistance

In this section common installation and runtime problems were explained. If, however, you encounter what you feel may be a problem with the software (bug), then please consult your dealer if you have the latest release of the software. Normally an update with fixes and upgrades will be issued **every 6 months.** If your problem is not covered by the latest software release as provided by your dealer, then please send:

1. the program and module version as shown in menu item “Help / About the program”,
2. the description of the operating system on your computer (e.g. Win95, WinNT4, Win2000, etc.)
3. a detailed description of the problem
4. the corresponding files (e.g. DXF, PRJ, etc.), and
5. the steps you had followed when the problem occurred as recorded by the program (if applicable).
   (To do this you may use the “Copy History” feature of the package to copy the procedure you followed when you encounter the problem to the clipboard. Paste the copied text in any document or text file and send it along with your notes.)

by e-mail to zach@mred.tuc.gr. or to mkarmis@vt.edu,

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