SCHOOL OF
CIVIL ENGINEERING

INDIANA
DEPARTMENT OF HIGHWAYS

INFORMATIONAL REPORT

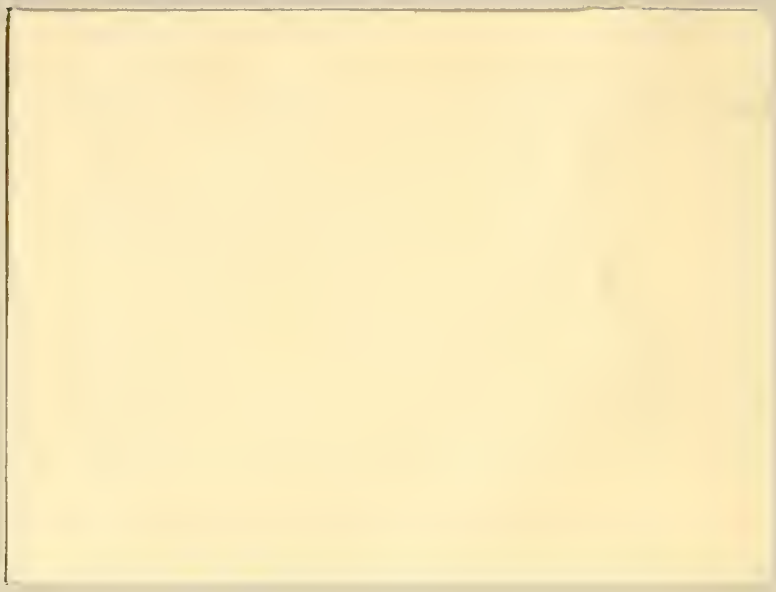
JHRP-85-7

PCSTABL4 USER MANUAL

James R. Carpenter

May 1985

PURDUE UNIVERSITY



INFORMATIONAL REPORT

JHRP-85-7

PCSTABL4 USER MANUAL

James R. Carpenter

May 1985

Information Report

PCSTABL4 USER MANUAL

by

James R. Carpenter
Graduate Instructor in Research

School of Civil Engineering
Purdue University
West Lafayette, Indiana 47907

File: 6-14-12

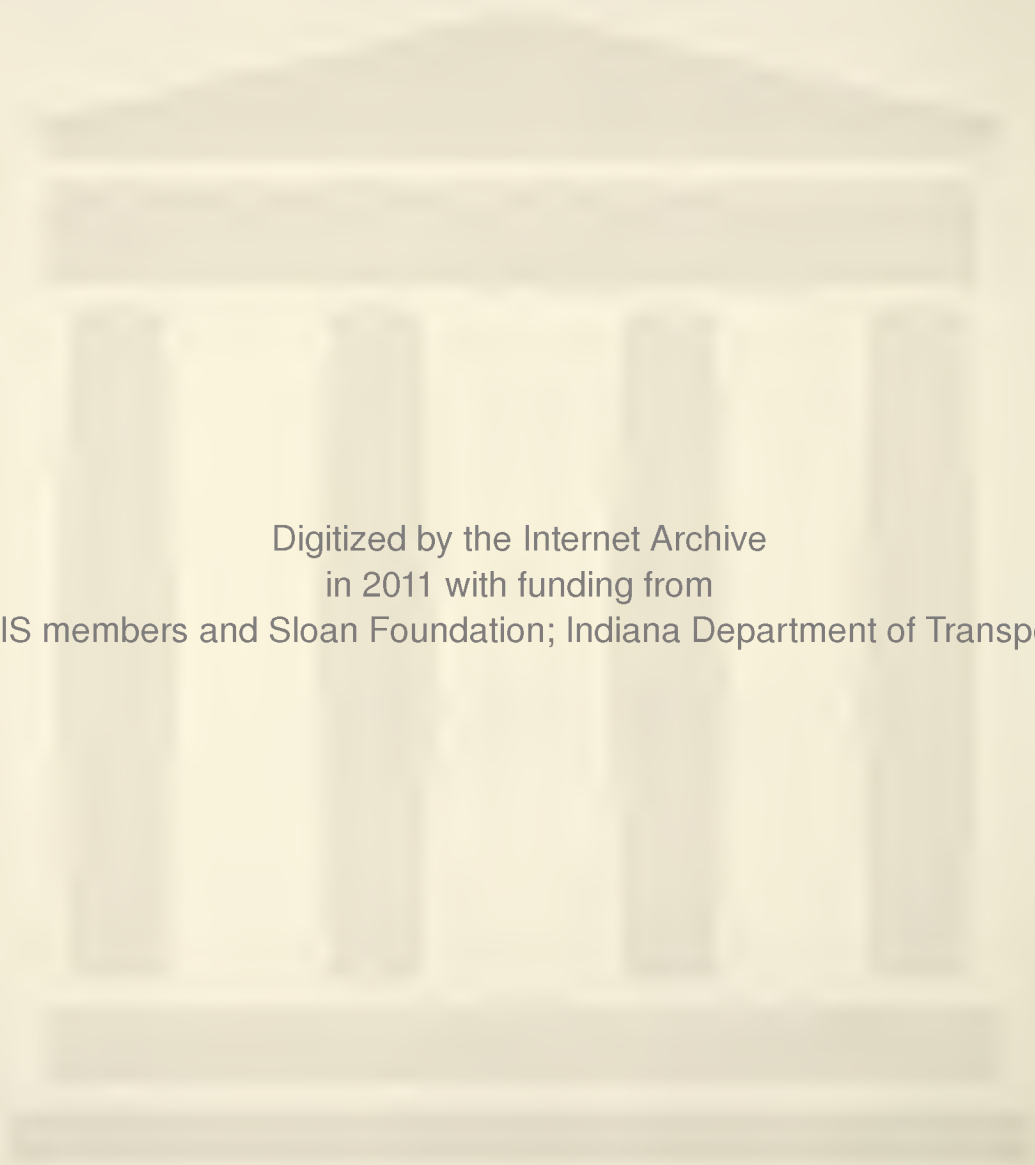
Prepared Under Contract for

Federal Highway Administration
U.S. Department of Transportation
Office of Research, Development & Technology
Washington, DC 20590

Published by

Joint Highway Research Project
Purdue University
West Lafayette, Indiana 47907

May 16, 1985



PCSTABL4 USER MANUAL

ABSTRACT

This report describes the operation of the two-dimensional, limiting equilibrium, slope stability program, PCSTABL4. A short review of the program's capabilities and hardware and software requirements are presented along with instructions for operating the program on a microcomputer. Three example problems are included to familiarize the user with the program. Appendix A lists the definitions of the variables and subroutines used in the program.

TABLE OF CONTENTS

I. INTRODUCTION

PCSTABL4 is a microcomputer version of the mainframe slope stability program, STABL4. The program is written in FORTRAN and calculates the factor of safety against slope failure by a two-dimensional limiting equilibrium method. The calculation of the factor of safety against slope instability is performed using either the Simplified Bishop method of slices, which is applicable to circular shaped failure surfaces, or the Simplified Janbu method of slices, which is applicable to failure surfaces of a general shape.

PCSTABL4 features unique techniques for random generation of potential failure surfaces for subsequent determination of the more critical failure surfaces and their corresponding factors of safety. Circular, irregular and sliding block surfaces may be generated and analyzed using either a random search technique or specific input of the coordinates of a given potential failure surface.

The program is capable of handling heterogeneous soil systems, anisotropic soil strength parameters, excess pore water pressure due to shear, static groundwater and surface water, pseudo-static earthquake loading, surcharge and tieback loading.

The tieback loading feature is a recent addition to STABL and provides for the input of horizontal or near horizontal tieback or line loads for analyzing the overall stability of tied-back or braced slopes and walls. PCSTABL4 and STABL4 are the only known computer programs with the ability to analyze

slopes subjected to tieback or concentrated loads using either the Simplified Janbu or Simplified Bishop method of slices.

Plotted output is provided as a visual aid to confirm the correctness of problem input data. Error messages are generated within the program to pinpoint locations where input data are inconsistent with PCSTABL4's input requirements. Free-format data input eases the task of input file preparation, which results in a reduction of input errors.

This manual is intended to describe execution of PCSTABL4 on a microcomputer, along with the capabilities, and hardware and software requirements of the program. Two other reference manuals are required for execution of PCSTABL4 on the microcomputer. These references describe the program's limitations, assumptions, creation of input files, and provide several example problems. These references are:

1). "STABL User Manual", JHRP-75-9;

2). "Introduction to Slope Stability Analysis with STABL4", JHRP-84-19.

Three other useful references are:

1). "Computer Analysis of General Slope Stability Problems", JHRP-75-8;

2). "Computerized Slope Stability Analysis for Indiana Highways", Vol. 1, JHRP-77-25; and

3). "Three-Dimensional Slope Stability Analysis", JHRP-81-17.

I.1 PCSTABL4 Versions

Two versions of PCSTABL4 are available for IBM compatible microcomputers.

Version 1.87 runs on any IBM compatible machine with the optional Intel 8087 Math Co-Processor. The program requires the Intel 8087 Math Co-Processor and will not run on IBM compatible machines without the 8087 math coprocessor. Version 1.87 has been compiled to utilize the Intel 8087 Math Co-Processor during execution which significantly enhances execution time.

Version 1.88 is supplied for those users who do not have the Intel 8087 Math Co-Processor. This version will run on any IBM compatible machine, however it is significantly slower than version 1.87 since it does not utilize the Intel 8087 Math Co-Processor. Version 1.88 will run on a machine with or without an 8087 coprocessor, however performance on a machine with an 8087 coprocessor will be the same as that on a machine without an 8087 coprocessor.

For faster execution on machines without the 8087 math coprocessor, the 1.88 version has been compiled using an alternate math library which sacrifices a small amount of precision in return for faster execution. The amount of error is very small and is not significant for engineering purposes, however results will vary somewhat from the 1.87 version.

Version 1.87 is strongly recommended since it will run 3 to 5 times faster than version 1.88 and does not sacrifice any accuracy. For example, a moderately complex problem which

generates and analyzes 100 failure surfaces takes approximately 4 minutes to run using the 8087 version (version 1.87), while the same problem takes approximately 12 minutes to run using the non-8087 version (version 1.88).

I.2 Comparison of PCSTABL4 AND STABL4

PCSTABL4 is a microcomputer version of the mainframe STABL4 program. PCSTABL4 contains all the options and capabilities of STABL4 including:

- Simplified Janbu or Bishop method of slices
- Isotropic and anisotropic soil parameters
- Piezometric water surfaces
- Specific surface or random search surface generation
- Circular, random or block potential failure surfaces
- Tieback, surcharge and earthquake loads

The only notable difference between PCSTABL4 and STABL4 is that the random number generator from STABL3 has been utilized in PCSTABL4, since the random number generator used in STABL4 is not compatible with the IBM microcomputer. Therefore, slight differences may be noticed in the failure surfaces generated and the factors of safety calculated, when comparing the results obtained from PCSTABL4 and STABL4.

The variable definitions have been removed from the source code listing to save storage space and are included in Appendix A. In addition, the source code has been renumbered.

Plotting routines are also available for driving the Hewlett-Packard HP-7470A two-pen plotter and will be discussed in Section III.

I.3 Availability of Program

PCSTABL4 is supplied on two 5 1/4 inch double-sided, double-density, floppy diskettes, and one single-sided, double-density, floppy diskette. The program is available for all versions of IBM and MS-DOS disk operation systems (DOS), including DOS 1.0 through DOS 3.0. The program is supplied to all private firms by Purdue University and may be obtained by contacting:

James R. Carpenter or Prof. C.W. Lovell
Grissom Hall, School of Civil Engineering
Purdue University
West Lafayette, Indiana 47907
Phone: (317) 494-5025 (or 5034)

The program is available to all state highway agencies through the Federal Highway Administration and may be obtained by contacting:

Mr. Chien-Tan Chang
Research Development and Technology
Office of Implementation (HRT-10)
FHWA US DOT
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, Virginia 22101
Phone: (703) 285-2357

(BLANK PAGE)

II. RUNNING PCSTABL4

II.1 Hardware and Software Requirements

The following is a list of the minimum hardware requirements for operating PCSTABL4.

1. One IBM or IBM compatible microcomputer[1]
2. 256 kilobytes of random access memory
3. One double-sided, double density disk drive
4. One 80 column monochrome display
5. One dot matrix printer
   carriage)

The following hardware items are optional for operating PCSTABL4, but are strongly recommended for maximum operating efficiency. These items are discussed further in other sections.

1. One Intel 8087 Math Co-Processor
2. One Hewlett-Packard 7470A two-pen plotter

PCSTABL4 will run on machines using any IBM or MS-DOS disk operating system (DOS), including DOS versions 1.0 to 3.0. Software requirements for using PCSTABL4 include:

---

[1] PCSTABL4 has been successfully tested on the following IBM compatible microcomputers. This list is not comprehensive and is subject to update as PCSTABL4 is used on more computers.

IBM: PC, XT, AT, Portable
Zenith: Z150, (Z100)
Compaq: Portable, (Deskpro)
Kaypro: Model 16
TeleVideo: Model 1605
Seequa: Chameleon Plus

1. A line editor or word processor for creating input files,

2. A BASIC interpreter (IBM-BASIC or GW-BASIC: Only required if using optional plotting routine, PLOTSTBL)

Color monitors, hard disk drives, other types of printers, additional memory space and the like, may enhance the efficiency of PCSTABL4, but are not required.

II.2 Diskette Contents

PCSTABL4 is supplied on two 5 1/4 inch double-sided, double-density, floppy diskettes, and one single-sided, double-density, floppy diskette. The contents of these diskettes are listed below:

DISK #1:

PCSTABL4.EXE	Executable Program
EXAMPLE1.IN EXAMPLE2.IN EXAMPLE3.IN	Example Input Files
EXAMPLE1.OUT EXAMPLE2.OUT EXAMPLE3.OUT	Example Output Files
EXAMPLE1.PLT EXAMPLE2.PLT EXAMPLE3.PLT	Example Plot Files
PLOTSTBL.BAS	Optional BASIC Plotting Routine

DISK #2:

87STABL4.FOR 87READ1.FOR 87READ2.FOR 87RAND.FOR 87SURF.FOR 87FACT.FOR	FORTRAN Source Code

DISK #3:

87MISC.FOR 87PLOT.FOR	FORTRAN Source Code

The FORTRAN source code of PCSTABL4 has been divided into the eight files listed above. Source code files for the 1.87[2] version have an 87 prefix, while source code files for the 1.88 version have an 88 prefix. These files were compiled and linked together into the executable program PCSTABL4.EXE using the Microsoft FORTRAN compiler, version 3.2. The Microsoft compiler however is not required for running the program, and is only required if the user makes changes in the program. Note that only DISK #1 is required to run PCSTABL4.

It is strongly recommended that the user create backup copies of the original diskettes supplied, and use these copies for day-to-day use, while saving the original diskettes for permanent storage.

II.3 Creation of Input Files

Input files for PCSTABL4 utilize free-format data entry, as used by previous mainframe versions of STABL. Input files may be created using a line editor, text editor, or a word processor. Since word processors generally store format characters along with the text, input files must be saved without any formatting so that format characters will not be encountered when running the program. If such characters are encountered, execution errors will result.

The user is referred to the "STABL User Manual" and the "Introduction to Slope Stability Analysis with STABL4" references for proper formatting of input data.

---

[2] Refer to the end of Appendix A for a list of non-FORTRAN statements used in the 8087 version (version 1.87).

II.4 Sample Terminal Session

Operation of PCSTABL4 is very simple. After creating an input file and storing it on a diskette, simply type "PCSTABL4" in either uppercase or lowercase letters followed by a return. The program will be loaded into memory and will prompt the user for the current date, time, name of the user, input filename, output filename, and filename for subsequent plotting of output. The date, time, and name of the user may be in any form desired. Note that the input and output files do not need to be on the same diskette or disk drive with PCSTABL4, as supplied on DISK #1. Disk drive specifications may be used when invoking PCSTABL4 (i.e., B:PCSTABL4), or when specifying input and output files (i.e., A:EXAMPLE1.OUT). In addition, if an invalid or nonexistent input filename is specified, the operating system will display an error message to the screen and return the user to the DOS prompt.

Filenames for the output file and the plotted output file may be any legal DOS filename. Note that an existing output file on a diskette will be overwritten if an existing output filename is reused. To avoid overwriting existing files, use unique names for each output. All responses to prompts may be uppercase or lowercase characters, including numbers and legal DOS filename symbols.

The program will write the output to the screen and the disk simultaneously. This includes the input parameters, method of analysis, and results. When running a problem which analyzes many surfaces, no output will be written to the

screen while trial failure surfaces are being generated and analyzed. After all surfaces have been generated and analyzed, and the ten most critical factors of safety sorted, the program will resume displaying the results to the screen.

If a plotted output file is specified, the program will write commands and sets of coordinates to the disk for subsequent plotting by the PLOTSTBL.BAS program on a Hewlett-Packard plotter. If a plotted output file is not desired, simply type "None" when prompted for the plotted output filename. To save diskette space, only specify a plotted output file for those runs whose outputs will be plotted using PLOTSTBL. Note that plotting is not performed during execution of PCSTABL4. This allows the user to examine the results, and plot only those results which are desired.

The following portion of this section is a sample terminal session using the input file EXAMPLE1.IN supplied on DISK #1. The output from this run is named EXAMPLE1.OUT on DISK #1 and is also shown as Example #1 in Section IV. The plotted output file, EXAMPLE1.PLT, also appears on DISK #1. Note that by running this example using the filenames shown, the output files EXAMPLE1.OUT and EXAMPLE1.PLT supplied on DISK #1, will be overwritten. All user responses to prompts are underlined in the sample terminal session.

ISOTROPIC SOIL PARAMETERS

1 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	125.0	.0	18.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	10.00	35.00
2	50.00	35.00
3	50.01	50.00
4	82.00	51.00

TIEBACK LOAD(S)

2 Tieback Load(s) Specified

Tieback No.	X-Pos (ft)	Y-Pos (ft)	Load (lbs)	Spacing (ft)	Inclination (deg)	Length (ft)
1	50.07	53.00	150000.0	10.0	.00	40.0
2	50.05	48.00	200000.0	10.0	15.00	30.0

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

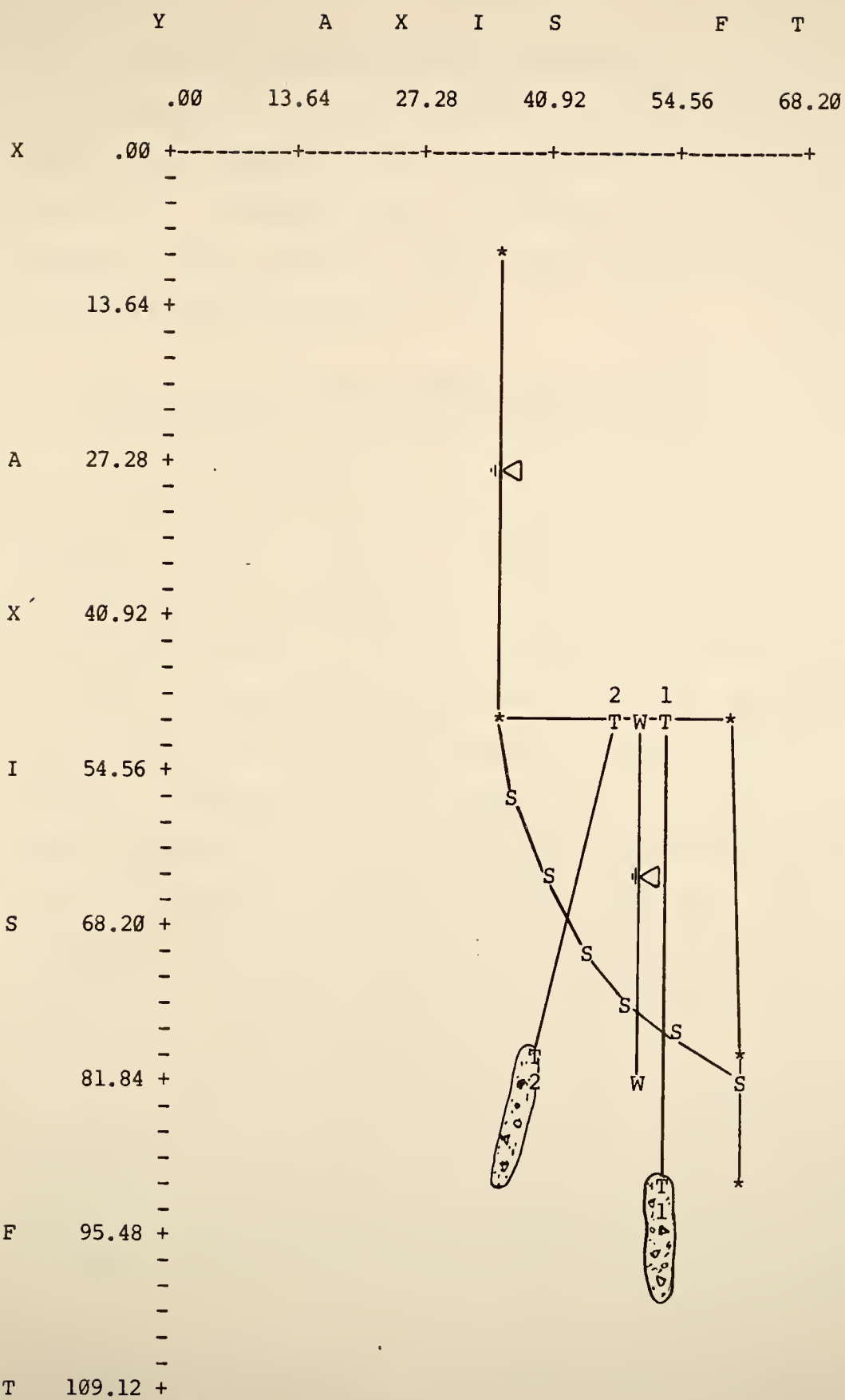
Trial Failure Surface Specified By 7 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	50.00	35.00
2	56.00	36.80
3	64.00	40.90
4	70.00	45.10
5	74.00	49.00
6	78.00	54.10
7	82.30	62.00

Circle Center At X = 41.0 ; Y = 76.0 and Radius, 41.9

Factor Of Safety For The Preceding Specified Surface = 1.870

WARNING - Factor Of Safety Is Calculated By The Modified Bishop Method. This Method Is Valid Only If The Failure Surface Approximates A Circle.



Stop - Program terminated.

(BLANK PAGE)

III. OPTIONAL PLOTTING ROUTINE - PLOTSTBL

PLOTSTBL is a BASIC program for plotting the graphical output from PCSTABL4 using a Hewlett-Packard HP-7470A two-pen plotter[3]. PLOTSTBL reads the plotted output file created by PCSTABL4 which contains three letter commands and coordinates for plotting by PLOTSTBL.

III.1 Hardware and Software Requirements

The only hardware required for plotting graphical output is a Hewlett-Packard HP-7470A two-pen plotter. PLOTSTBL is written such that the plotter must be configured to a baud rate of 9600 and connected to serial communication port #2 on the microcomputer. If the user desires to connect the plotter to serial communication port #1, the user must modify the first line of the PLOTSTBL program to read "com1" instead of "com2". Likewise, if the user desires to use a baud rate other than 9600, the user must replace the "9600" in the first line of PLOTSTBL with the desired baud rate. For further information on interfacing an HP plotter with the user's specific microcomputer, the user should consult his or her own plotter and microcomputer manuals.

The only software required to run PLOTSTBL is a BASIC interpreter (IBM-BASIC or GW-BASIC), which is normally supplied along with the disk operating system upon purchase of an IBM or IBM compatible microcomputer.

---

[3] Slight modifications to PLOTSTBL may be required for plotting graphical output using other HP plotters.

III.2 Sample Terminal Session

The following sample terminal session uses the plotted output file EXAMPLE2.PLT found on DISK #1. To run PLOTSTBL, invoke the BASIC interpreter by typing "BASIC", load the PLOTSTBL program by hitting the "F3" (LOAD) key and type "PLOTSTBL". To begin plotting, hit the "F2" (RUN) key and answer the prompts.

The program will prompt the user for the name of the input file to be used for plotting, (in this case "A:EXAMPLE2.PLT"), the title of the plot, a request for pen changes, and units for labelling the plot. As with PCSTABL4, disk drive specifications may be used when invoking PLOTSTBL or specifying the input file. The file to be used for plotting must be an existing file on diskette. If the input file specified for plotting is nonexistent, the interpreter will display the error message, "File not found in 390". The user must then hit the "F2" key to restart PLOTSTBL. The title of the plot may contain uppercase and lowercase letters, numbers and symbols, and will appear at the top of the plot.

The user may enhance the plot by specifying that the program prompt the user for pen changes during plotting. This allows the user to use various colors and pen thicknesses during plotting. PLOTSTBL is written so that the user is not restricted to two pens during plotting, but may use any number of pens. The program will stop during execution, return the pen to its holder, and prompt the user for a pen change for a particular set of line segments (i.e., boundaries, water

surfaces, etc.). The user then replaces the desired pen in the user specified pen holder, and the program continues plotting. The user may also specify that no pen changes are desired. In this case, only the left pen (Pen #1) will be used for the entire plot.

For convenience, an option for specifying the units of the plot is provided. The user may specify that the plot be labelled in either "Feet" or "Meters". Note that specifying either unit does not alter the plot, only the label on the axes of the plot.

For outputs where more than ten surfaces have been generated, two plots will be produced. The first plot will contain all the surfaces generated, while the second plot will contain only the ten most critical surfaces. The user will be prompted to change the paper and place the desired pen for the axes of the plot in pen holder #1.

The remainder of this section is a sample terminal session for plotting. All user responses to prompts are underlined.

```
B>BASIC

The IBM Personal Computer Basic
Version D2.10 Copyright IBM Corp. 1981, 1982, 1983
60891 Bytes free

Ok
LOAD"A:PLOTSTBL
Ok
RUN
```

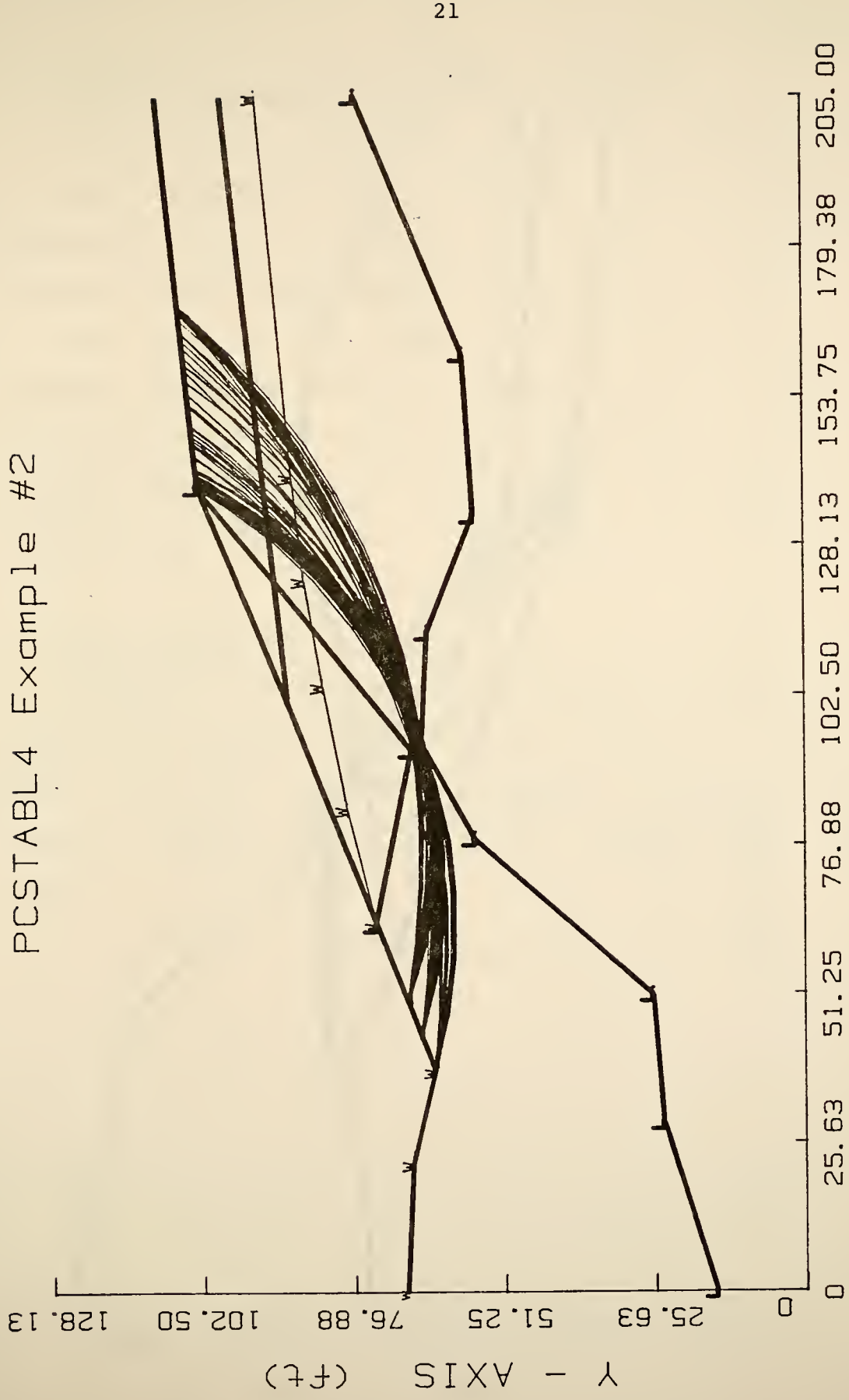
PCSTABL4

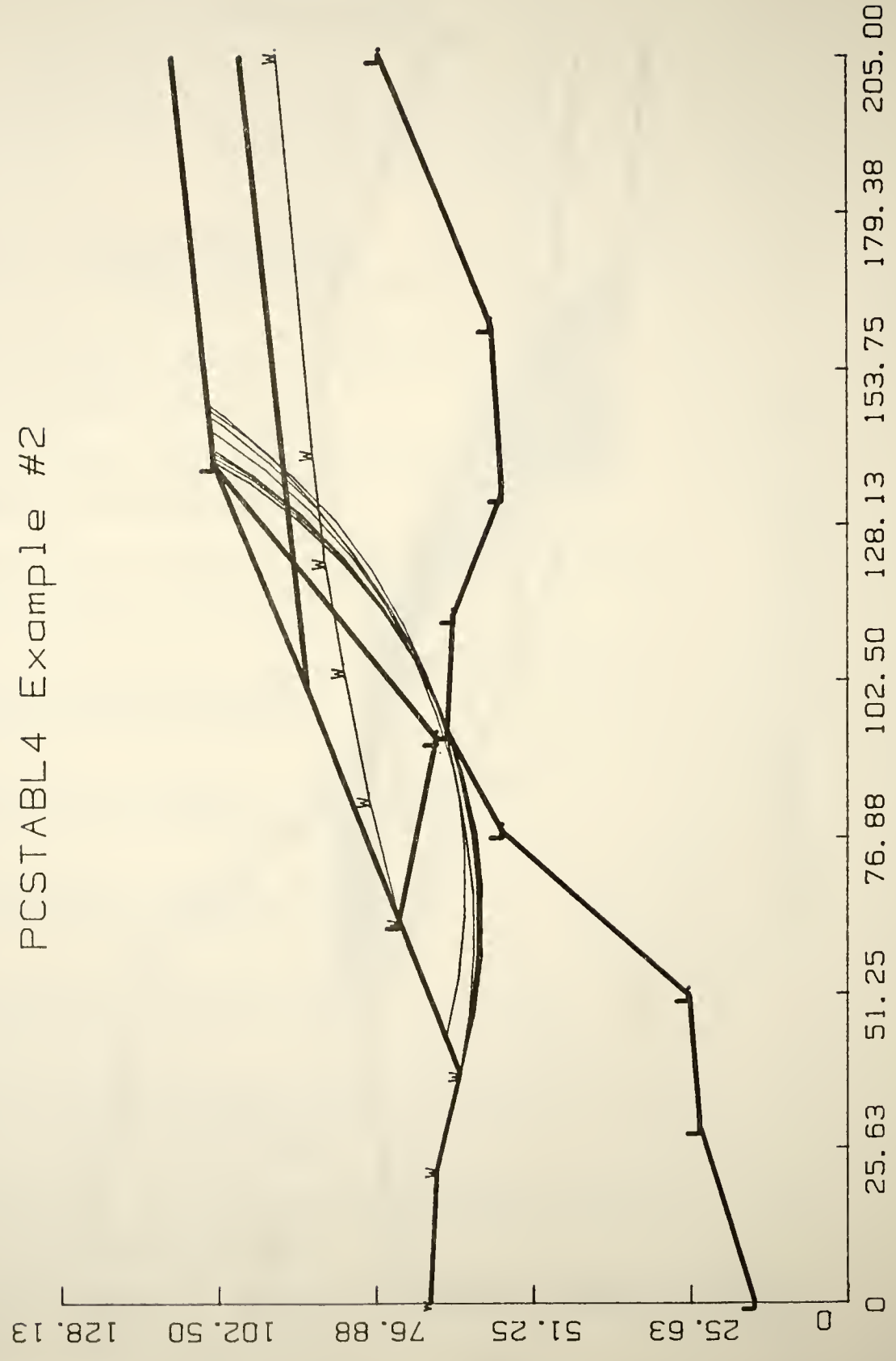
PLOTTING ROUTINES

by

PURDUE UNIVERSITY

```
Filename to be Plotted ? A:EXAMPLE2.PLT
Title for Plot ? PCSTABL4 Example #2
Do You Want to be Prompted for Pen Changes? (y/n) ? y
Is Plot in Feet or Meters (f/m) ? f

SELECT PEN FOR PLOTTING PROFILE (1 OR 2) ? 2
 INSERT DESIRED PEN IN PEN HOLDER #  2
 HIT ANY KEY TO CONTINUE WHEN READY

SELECT PEN FOR PLOTTING WATER SURFACES (1 OR 2) ? 1
 INSERT DESIRED PEN IN PEN HOLDER #  1
 HIT ANY KEY TO CONTINUE WHEN READY

SELECT PEN FOR PLOTTING SEARCHING BOUNDARY LIMITS (1 OR 2) ? 2
 INSERT DESIRED PEN IN PEN HOLDER #  2
 HIT ANY KEY TO CONTINUE WHEN READY

SELECT PEN FOR PLOTTING TRIAL FAILURE SURFACES (1 OR 2) ? 1
 INSERT DESIRED PEN IN PEN HOLDER #  1
 HIT ANY KEY TO CONTINUE WHEN READY

 Change Paper for Next Plot
 PLACE PEN FOR PLOTTING BORDER IN PEN HOLDER #1
 Hit Any Key to Continue When Ready

SELECT PEN FOR PLOTTING PROFILE (1 OR 2) ? 2
 INSERT DESIRED PEN IN PEN HOLDER #  2
 HIT ANY KEY TO CONTINUE WHEN READY

SELECT PEN FOR PLOTTING WATER SURFACES (1 OR 2) ? 1
 INSERT DESIRED PEN IN PEN HOLDER #  1
 HIT ANY KEY TO CONTINUE WHEN READY

SELECT PEN FOR PLOTTING SEARCHING BOUNDARY LIMITS (1 OR 2) ? 2
 INSERT DESIRED PEN IN PEN HOLDER #  2
 HIT ANY KEY TO CONTINUE WHEN READY

SELECT PEN FOR MOST CRITICAL TRIAL FAILURE SURFACE (1 OR 2)? 1
 INSERT DESIRED PEN IN PEN HOLDER #  1
 HIT ANY KEY TO CONTINUE WHEN READY

SELECT PEN FOR REMAINDER OF CRITICAL TRIAL FAILURE SURFACES (1 OR 2)? 1
 INSERT DESIRED PEN IN PEN HOLDER #  1
 HIT ANY KEY TO CONTINUE WHEN READY

 PLOTTING COMPLETE
Ok
```


PCSTABL4 Example #2
Y - AXIS (ft)
128.13
102.50
76.88
51.25
25.63
0
X - AXIS (ft)
0
25.63
51.25
76.88
102.50
128.13
153.75
179.38
205.00


PCSTABL4 Example #2
Y - AXIS (ft)
128.13
102.50
76.88
51.25
25.63
0
X - AXIS (ft)
0
25.63
51.25
76.88
102.50
128.13
153.75
179.38
205.00

IV. EXAMPLE PROBLEMS USING PCSTABL4 & PLOTSTBL

The following examples are included to help familiarize the user with PCSTABL4 and PLOTSTBL. These examples are described in detail in previous STABL manuals and the user is referred to the appropriate references for each example.

The 1.87 version (8087 version) was used for the following examples. Slightly different trial failure surfaces and factors of safety will be obtained using version 1.88 (non-8087 version) since this version is slightly less accurate than version 1.87.

IV.1 Example #1

Example #1 is taken from "Introduction to Slope Stability Analysis with STABL4", Tieback Example Problem #1. The input, output, and plotted output files appear on DISK #1, and are labelled EXAMPLE1.IN, EXAMPLE1.OUT, EXAMPLE1.PLT, respectively.

```
PROFIL
PCSTABL4 Example #1
4 4
10. 35. 50. 35. 1
50. 35. 50.1 60. 1
50.1 60. 80. 62. 1
80. 62. 92. 62. 1
SOIL
1
120. 125. 0. 18. 0. 0. 1
WATER
1 62.4
4
10. 35.
50. 35.
50.01 50.
82. 51.
TIES
2
2 53. 150000. 10. 0. 40.
2 48. 200000. 10. 15. 30.
SURBIS
7
50. 35.2
56. 36.8
64. 40.9
70. 45.1
74. 49.
78. 54.1
82.3 62.
EXECUT
```

** PCSTABL4 **

by
Purdue University

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

Run Date: 2/3/85
Time of Run: 6:30 pm
Run By: Jim Carpenter
Input Data Filename: EXAMPLE1.IN
Output Filename: EXAMPLE1.OUT
Plotted Output Filename: EXAMPLE1.PLT

PROBLEM DESCRIPTION PCSTABL4 Example #1

BOUNDARY COORDINATES

4 Top Boundaries
4 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	10.00	35.00	50.00	35.00	1
2	50.00	35.00	50.10	60.00	1
3	50.10	60.00	80.00	62.00	1
4	80.00	62.00	92.00	62.00	1

ISOTROPIC SOIL PARAMETERS

1 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez Surface No.
1	120.0	125.0	.0	18.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	10.00	35.00
2	50.00	35.00
3	50.01	50.00
4	82.00	51.00

TIEBACK LOAD(S)

2 Tieback Load(s) Specified

Tieback No.	X-Pos (ft)	Y-Pos (ft)	Load (lbs)	Spacing (ft)	Inclination (deg)	Length (ft)
1	50.07	53.00	150000.0	10.0	.00	40.0
2	50.05	48.00	200000.0	10.0	15.00	30.0

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

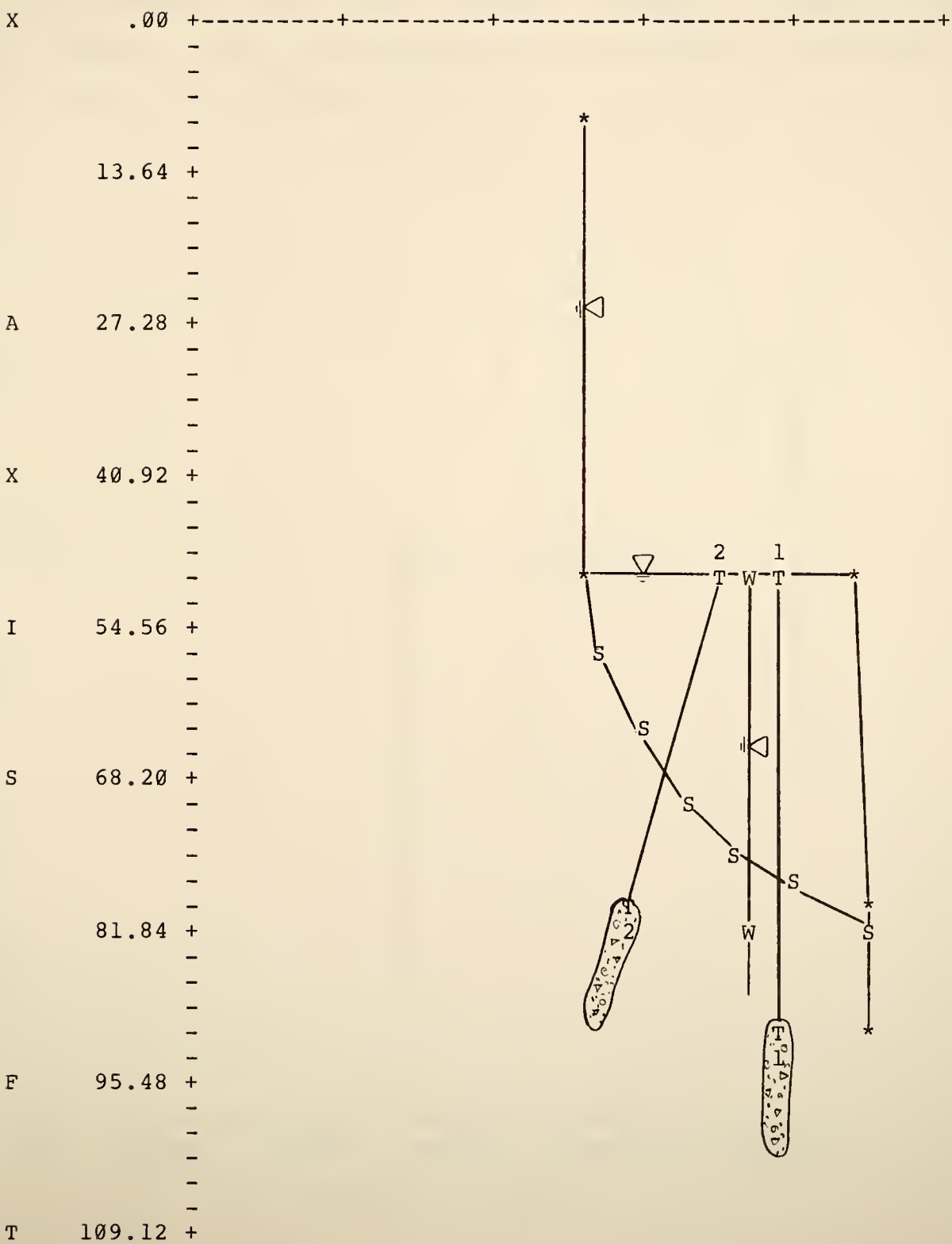
Trial Failure Surface Specified By 7 Coordinate Points

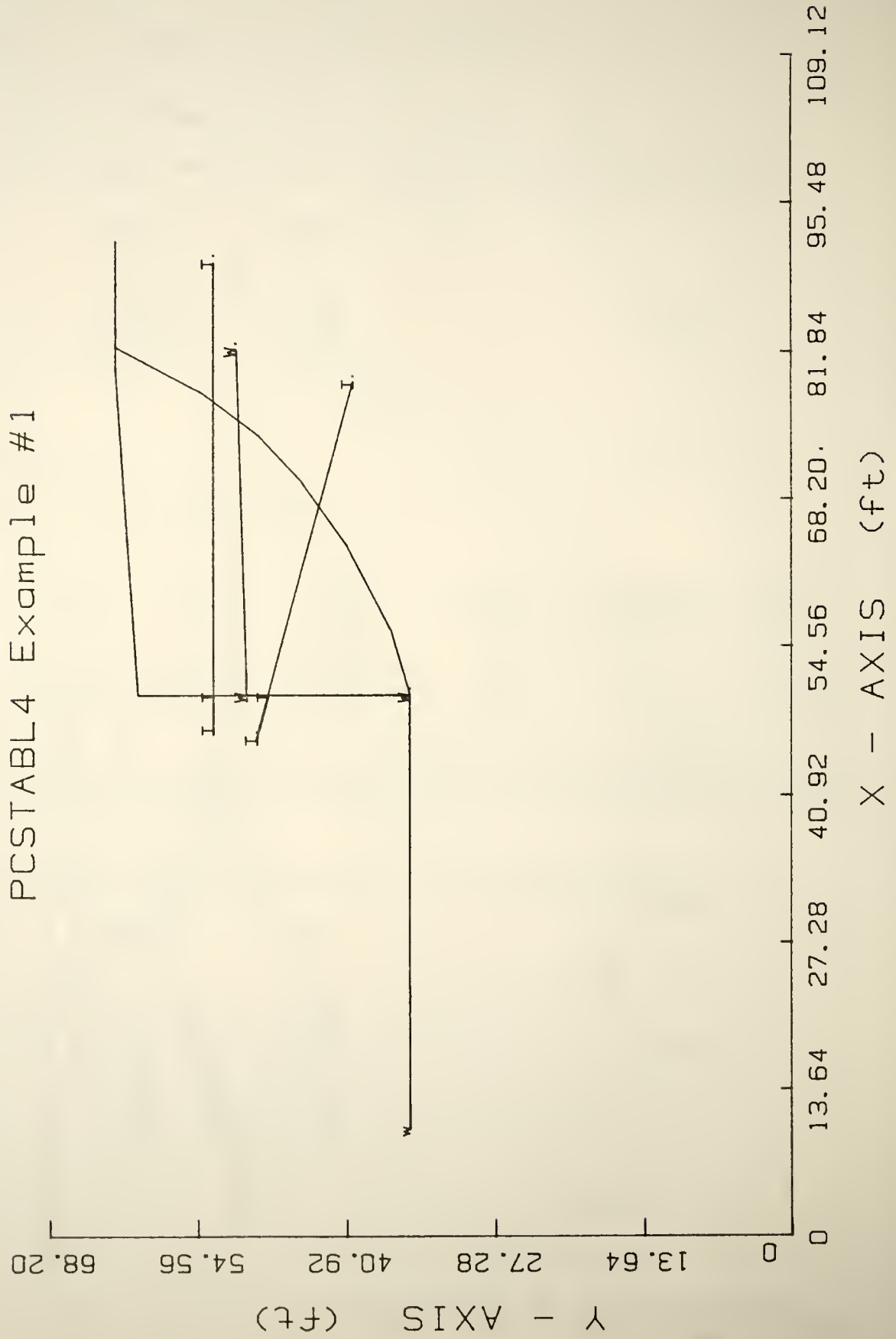
Point No.	X-Surf (ft)	Y-Surf (ft)
1	50.00	35.00
2	56.00	36.80
3	64.00	40.90
4	70.00	45.10
5	74.00	49.00
6	78.00	54.10
7	82.30	62.00

Circle Center At X = 41.0 ; Y = 76.0 and Radius, 41.9

Factor Of Safety For The Preceding Specified Surface = 1.870

WARNING - Factor Of Safety Is Calculated By The Modified Bishop Method. This Method Is Valid Only If The Failure Surface Approximates A Circle.


Y A X I S F T
.00 13.64 27.28 40.92 54.56 68.20
X .00
13.64
A 27.28
X 40.92
I 54.56
S 68.20
81.84
F 95.48
T 109.12
2
1
T
W
T
S
S
S
S
S
S
W
S
2
T1


PCSTABL4 Example #1
Y - AXIS (ft)
68.20
54.56
40.92
27.28
13.64
0
X - AXIS (ft)
0
13.64
27.28
40.92
54.56
68.20.
81.84
95.48
109.12

IV.2 Example #2

Example #2 is taken from the "STABL User Manual", Example Problem #2. The input, output, and plotted output files appear on DISK #1, and are labelled EXAMPLE2.IN, EXAMPLE2.OUT, EXAMPLE2.PLT, respectively.

```
PROFIL
PCSTABL4 Example #2
6 5
0. 68. 22. 67. 1
22. 67. 38. 63. 1
38. 63. 101. 88. 1
101. 88. 138. 103. 2
138. 103. 205. 110. 2
101. 88. 205. 99. 1
SOIL
2
116.4 124.2 500. 14. 0. 0. 1
116.4 116.4 0. 0. 0. 0. 1
WATER
1 0.
9
0. 68.
22. 67.
38. 63.
63. 73.
83. 78.
104. 82.
122. 85.
140. 87.
205. 93.
LIMITS
10 8
0. 15. 29. 24.
29. 24. 51. 26.
51. 26. 78. 56.
78. 56. 94. 65.
94. 65. 113. 64.
113. 64. 133. 56.
133. 56. 161. 58.
161. 58. 205. 76.
63. 73. 93. 67.
93. 67. 138. 103.
CIRCLE
3 25
38. 50. 138. 170.
0. 10. 0. -25.
```

** PCSTABL4 **

by
Purdue University

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

Run Date: 3/3/85
Time of Run: 5:25 pm
Run By: Jim Carpenter
Input Data Filename: EXAMPLE2.IN
Output Filename: EXAMPLE2.OUT
Plotted Output Filename: EXAMPLE2.PLT

PROBLEM DESCRIPTION PCSTABL4 Example #2

BOUNDARY COORDINATES

5 Top Boundaries
6 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	68.00	22.00	67.00	1
2	22.00	67.00	38.00	63.00	1
3	38.00	63.00	101.00	88.00	1
4	101.00	88.00	138.00	103.00	2
5	138.00	103.00	205.00	110.00	2
6	101.00	88.00	205.00	99.00	1

ISOTROPIC SOIL PARAMETERS

2 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	116.4	124.2	500.0	14.0	.00	.0	1
2	116.4	116.4	.0	.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 9 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	68.00
2	22.00	67.00
3	38.00	63.00
4	63.00	73.00
5	83.00	78.00
6	104.00	82.00
7	122.00	85.00
8	140.00	87.00
9	205.00	93.00

Searching Routine Will Be Limited To An Area Defined By 10 Boundaries Of Which The First 8 Boundaries Will Deflect Surfaces Upward

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)
1	.00	15.00	29.00	24.00
2	29.00	24.00	51.00	26.00
3	51.00	26.00	78.00	56.00
4	78.00	56.00	94.00	65.00
5	94.00	65.00	113.00	64.00
6	113.00	64.00	133.00	56.00
7	133.00	56.00	161.00	58.00
8	161.00	58.00	205.00	76.00
9	63.00	73.00	93.00	67.00
10	93.00	67.00	138.00	103.00

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

75 Trial Surfaces Have Been Generated.

25 Surfaces Initiate From Each Of 3 Points Equally Spaced
Along The Ground Surface Between X = 38.00 ft.
and X = 50.00 ft.

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

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = .00 ft.

10.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation.
The Angle Has Been Restricted Between The Angles Of -25.0
And .0 deg.

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

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

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	38.00	63.00
2	47.79	60.95
3	57.74	59.93
4	67.74	59.93
5	77.68	60.96
6	87.47	63.00
7	97.00	66.04
8	106.16	70.05
9	114.86	74.97
10	123.01	80.77
11	130.52	87.37
12	137.32	94.71
13	143.32	102.71
14	143.86	103.61

*** 1.256 ***

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	38.00	63.00
2	47.82	61.12
3	57.78	60.20
4	67.78	60.26
5	77.73	61.29
6	87.53	63.28
7	97.08	66.22
8	106.31	70.08
9	115.12	74.81
10	123.43	80.38
11	131.15	86.73
12	138.22	93.80
13	144.57	101.53
14	146.13	103.85

*** 1.258 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	38.00	63.00
2	47.75	60.79
3	57.69	59.66
4	67.69	59.63
5	77.63	60.70
6	87.40	62.85
7	96.87	66.07
8	105.92	70.31
9	114.46	75.51
10	122.38	81.62
11	129.57	88.57
12	135.96	96.26
13	140.58	103.27

*** 1.267 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	38.00	63.00
2	47.74	60.74
3	57.68	59.59
4	67.68	59.54
5	77.62	60.60
6	87.38	62.77
7	96.84	66.00
8	105.89	70.27
9	114.40	75.51
10	122.28	81.67
11	129.42	88.67
12	135.75	96.42
13	140.14	103.22

*** 1.268 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	38.00	63.00
2	47.76	60.83
3	57.70	59.74
4	67.70	59.74
5	77.64	60.83
6	87.41	62.99
7	96.88	66.20
8	105.94	70.43
9	114.49	75.61
10	122.43	81.70
11	129.65	88.61
12	136.08	96.27
13	140.78	103.29

*** 1.270 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	38.00	63.00
2	47.73	60.71
3	57.67	59.53
4	67.67	59.48
5	77.61	60.55
6	87.37	62.74
7	96.82	66.01
8	105.84	70.32
9	114.32	75.62
10	122.15	81.84
11	129.22	88.91
12	135.46	96.72
13	139.50	103.16

*** 1.272 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	38.00	63.00
2	47.72	60.66
3	57.65	59.45
4	67.65	59.38
5	77.59	60.47
6	87.34	62.69
7	96.77	66.01
8	105.76	70.40
9	114.18	75.78
10	121.93	82.10
11	128.91	89.27
12	135.01	97.19
13	138.54	103.06

*** 1.278 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	44.00	65.38
2	53.77	63.26
3	63.71	62.18
4	73.71	62.15
5	83.66	63.19
6	93.44	65.26
7	102.95	68.36
8	112.08	72.45
9	120.72	77.47
10	128.79	83.39
11	136.18	90.12
12	142.83	97.59
13	147.40	103.98

*** 1.278 ***

Failure Surface Specified By 13 Coordinate Points

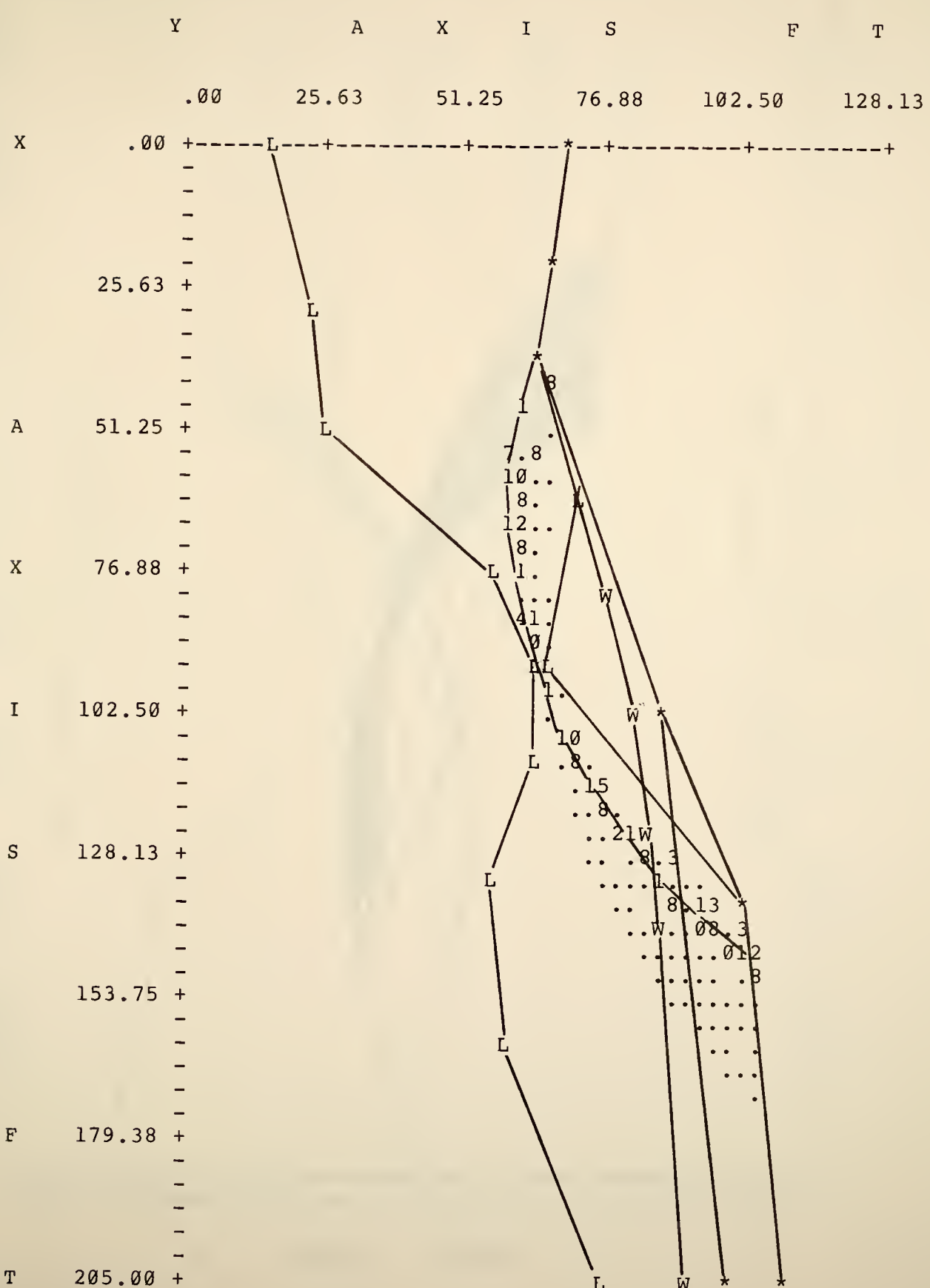
Point No.	X-Surf (ft)	Y-Surf (ft)
1	38.00	63.00
2	47.72	60.66
3	57.65	59.45
4	67.65	59.39
5	77.59	60.48
6	87.34	62.70
7	96.77	66.03
8	105.75	70.42
9	114.17	75.81
10	121.92	82.14
11	128.89	89.31
12	134.99	97.24
13	138.47	103.05

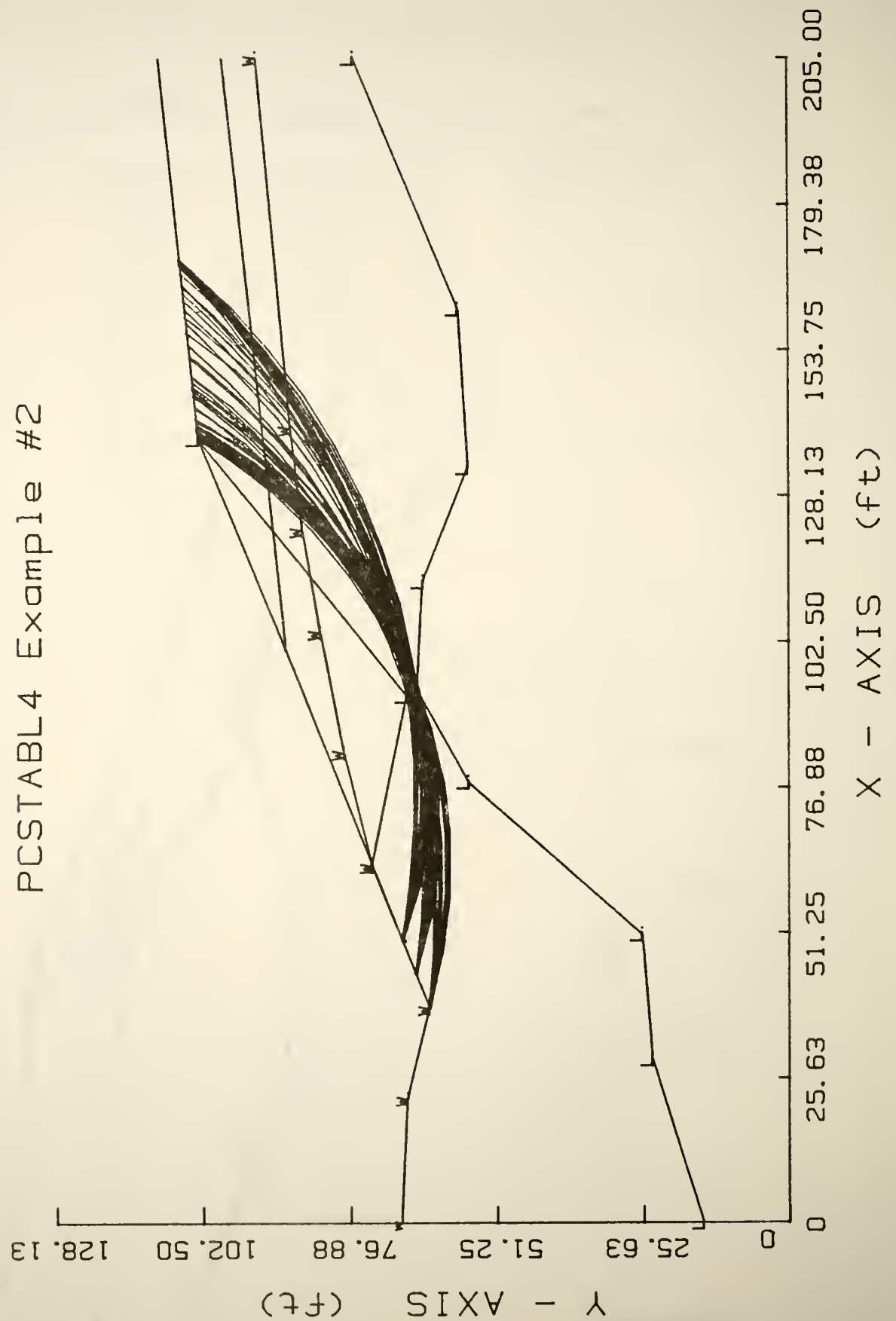
*** 1.279 ***

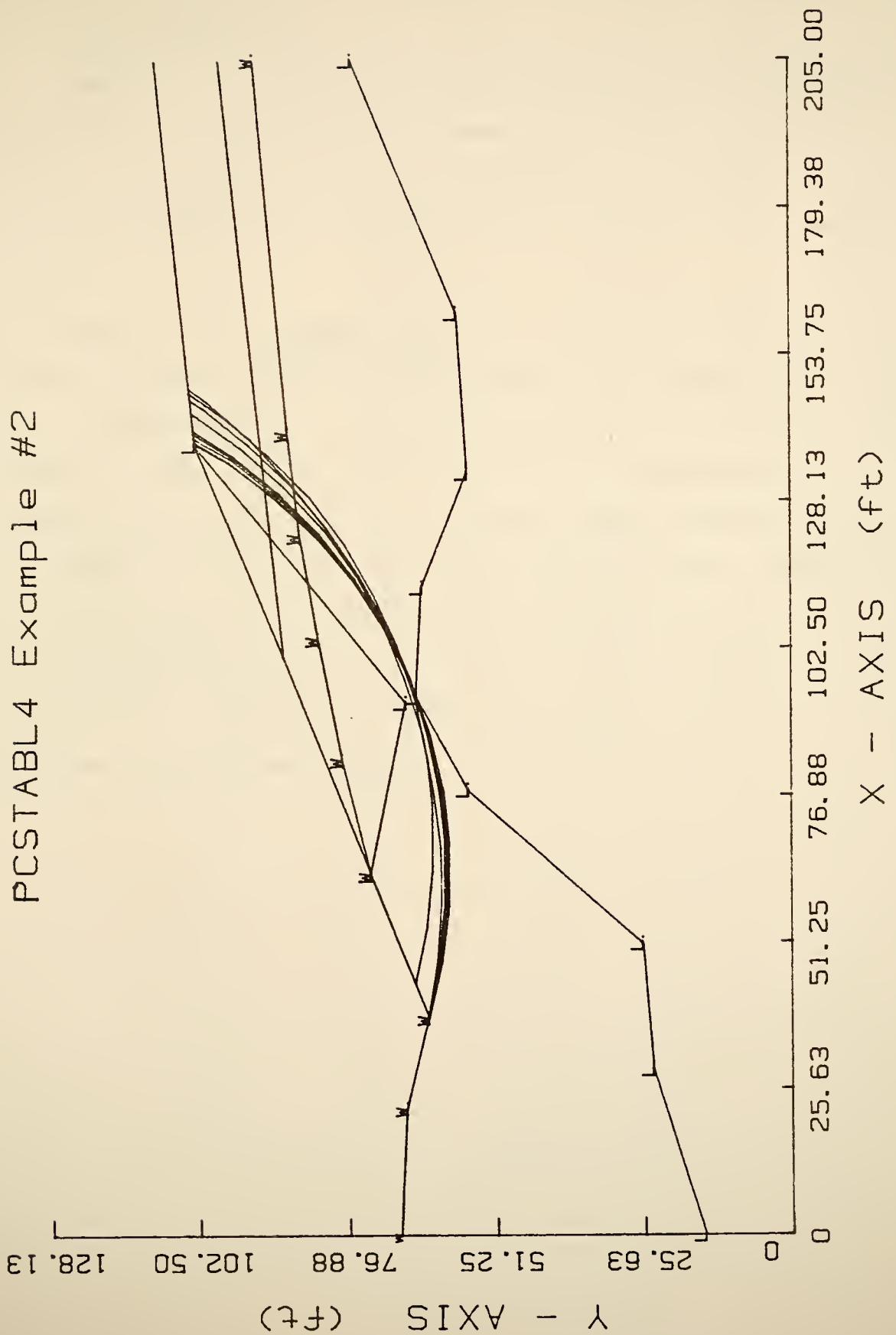
Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	38.00	63.00
2	47.88	61.44
3	57.86	60.78
4	67.85	61.02
5	77.79	62.16
6	87.58	64.19
7	97.15	67.09
8	106.42	70.84
9	115.32	75.41
10	123.76	80.76
11	131.70	86.85
12	139.05	93.63
13	145.76	101.04
14	148.02	104.05

*** 1.281 ***


Y A X I S F T
.00
25.63
51.25
76.88
102.50
128.13
X .00
25.63
A 51.25
X 76.88
I 102.50
S 128.13
153.75
F 179.38
T 205.00


PCSTABL4 Example #2
Y - AXIS (ft)
0
25.63
51.25
76.88
102.50
128.13
X - AXIS (ft)
0
25.63
51.25
76.88
102.50
128.13
153.75
179.38
205.00


PCSTABL4 Example #2
X - AXIS (ft)
0
25.63
51.25
76.88
102.50
128.13
153.75
179.38
205.00
Y - AXIS (ft)
0
25.63
51.25
76.88
102.50
128.13

(BLANK PAGE)

IV.3 Example #3

Example #3 is taken from "Introduction to Slope Stability Analysis with STABL4", Tieback Example Problem #3. The input, output, and plotted output files appear on DISK #1, and are labelled EXAMPLE3.IN, EXAMPLE3.OUT, EXAMPLE3.PLT, respectively.

Note that the factors of safety and the ten most critical failure surfaces shown in this output are somewhat different than those shown in "Introduction to Slope Stability with STABL4". The reason for these minor differences is that PCSTABL4 utilizes a slightly different random number generator than STABL4. If more trial failure surfaces were specified for this example (i.e. 50 surfaces) and run using both STABL4 and PCSTABL4, the differences in the ten most critical failure surfaces and resulting factors of safety between the two programs would be negligible.

```
PROFIL
TIEBACK EXAMPLE PROBLEM #3
14 8
0.0 24.0 12.0 24.0 2
12.0 24.0 19.5 30.0 2
19.5 30.0 19.6 31.5 5
19.6 31.5 22.5 34.0 5
22.5 34.0 24.0 34.0 5
24.0 34.0 34.0 42.0 2
34.0 42.0 46.0 52.0 1
46.0 52.0 100.0 52.0 1
34.0 42.0 100.0 42.0 2
24.0 34.0 25.5 32.5 5
19.5 30.0 20.8 28.6 2
20.8 28.6 25.5 32.5 2
0.0 16.0 100.0 25.0 3
0.0 8.0 100.0 20.0 4
SOIL
5
120. 125. 400. 26. 0. 0. 1
122. 127. 850. 30. 0. 0. 1
115. 120. 475. 0. 0. 0. 1
144. 147. 0. 45. 0. 0. 1
150. 150. 0. 0. 0. 0. 1
ANISO
1
2 2
-30. 600. 34.
90. 300. 28.
WATER
1 62.4
8
0. 24.
12. 24.
26. 30.
38. 34.
49. 37.
58. 39.
70. 40.
100. 40.
EQUAKE
.02 .02 0.
LOADS
2
50. 56. 100. 10.
56. 66. 200. 0.
TIES
1
4 32.5 300000. 10. 40. 45.
BLOCK2
25 2 6.
22. 14.5 24. 14.5 7.
70. 19.5 72. 19.5 5.
```

** PCSTABL4 **

by
Purdue University

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

Run Date:	2/3/85
Time of Run:	6:20 pm
Run By:	Jim Carpenter
Input Data Filename:	EXAMPLE3.IN
Output Filename:	EXAMPLE3.OUT
Plotted Output Filename:	EXAMPLE3.PLT

PROBLEM DESCRIPTION TIEBACK EXAMPLE PROBLEM #3

BOUNDARY COORDINATES

8 Top Boundaries
14 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	24.00	12.00	24.00	2
2	12.00	24.00	19.50	30.00	2
3	19.50	30.00	19.60	31.50	5
4	19.60	31.50	22.50	34.00	5
5	22.50	34.00	24.00	34.00	5
6	24.00	34.00	34.00	42.00	2
7	34.00	42.00	46.00	52.00	1
8	46.00	52.00	100.00	52.00	1
9	34.00	42.00	100.00	42.00	2
10	24.00	34.00	25.50	32.50	5
11	19.50	30.00	20.80	28.60	2
12	20.80	28.60	25.50	32.50	2
13	.00	16.00	100.00	25.00	3
14	.00	8.00	100.00	20.00	4

ISOTROPIC SOIL PARAMETERS

5 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	125.0	400.0	26.0	.00	.0	1
2	122.0	127.0	850.0	30.0	.00	.0	1
3	115.0	120.0	475.0	.0	.00	.0	1
4	144.0	147.0	.0	45.0	.00	.0	1
5	150.0	150.0	.0	.0	.00	.0	1

ANISOTROPIC STRENGTH PARAMETERS
1 soil type(s)

Soil Type 2 Is Anisotropic

Number Of Direction Ranges Specified = 2

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

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 8 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	24.00
2	12.00	24.00
3	26.00	30.00
4	38.00	34.00
5	49.00	37.00
6	58.00	39.00
7	70.00	40.00
8	100.00	40.00

A Horizontal Earthquake Loading Coefficient
Of .020 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of .020 Has Been Assigned

Cavitation Pressure = .0 psf

BOUNDARY LOAD(S)

2 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (lb/sqft)	Deflection (deg)
1	50.00	56.00	100.0	10.0
2	56.00	66.00	200.0	.0

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

TIEBACK LOAD(S)

1 Tieback Load(s) Specified

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

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

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

The Active And Passive Portions Of The Sliding Surfaces
Are Generated According To The Rankine Theory.

25 Trial Surfaces Have Been Generated.

2 Boxes Specified For Generation Of Central Block Base

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

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

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

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

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	5.22	24.00
2	6.11	23.49
3	11.31	20.49
4	16.50	17.49
5	17.98	16.00
6	22.22	11.76
7	70.01	18.08
8	74.26	22.32
9	74.65	22.72
10	77.65	27.91
11	80.65	33.11
12	83.65	38.31
13	85.79	42.00
14	88.96	47.09
15	92.03	52.00

*** 1.525 ***

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	4.88	24.00
2	5.82	23.46
3	11.02	20.46
4	16.21	17.46
5	18.23	15.44
6	22.48	11.19
7	71.22	19.90
8	73.98	22.66
9	76.98	27.85
10	79.98	33.05
11	82.98	38.25
12	85.14	42.00
13	88.32	47.09
14	91.39	52.00

*** 1.530 ***

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	5.71	24.00
2	6.54	23.52
3	11.73	20.52
4	16.93	17.52
5	18.13	16.33
6	22.37	12.08
7	71.64	20.30
8	74.00	22.66
9	77.00	27.86
10	80.00	33.05
11	83.00	38.25
12	85.17	42.00
13	88.35	47.09
14	91.42	52.00

*** 1.577 ***

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	6.61	24.00
2	7.32	23.59
3	12.51	20.59
4	17.71	17.59
5	19.27	16.03
6	23.51	11.79
7	70.36	17.63
8	74.61	21.87
9	75.53	22.80
10	78.53	27.99
11	81.53	33.19
12	84.53	38.39
13	86.62	42.00
14	89.80	47.09
15	92.87	52.00

*** 1.591 ***

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	6.73	24.00
2	7.42	23.60
3	12.62	20.60
4	17.81	17.60
5	19.57	15.85
6	23.81	11.60
7	70.49	18.16
8	74.73	22.40
9	75.09	22.76
10	78.09	27.95
11	81.09	33.15
12	84.09	38.35
13	86.20	42.00
14	89.38	47.09
15	92.45	52.00

*** 1.597 ***

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	7.30	24.00
2	7.91	23.65
3	13.10	20.65
4	18.30	17.65
5	18.80	17.15
6	23.04	12.90
7	70.19	21.82
8	70.73	22.37
9	73.73	27.56
10	76.73	32.76
11	79.73	37.95
12	82.07	42.00
13	85.25	47.09
14	88.32	52.00

*** 1.690 ***

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	7.55	24.00
2	8.13	23.67
3	13.32	20.67
4	18.52	17.67
5	22.59	13.59
6	71.57	17.98
7	75.81	22.22
8	76.47	22.88
9	79.47	28.08
10	82.47	33.27
11	85.47	38.47
12	87.51	42.00
13	90.69	47.09
14	93.76	52.00

*** 1.706 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	7.50	24.00
2	8.08	23.66
3	13.28	20.66
4	18.47	17.66
5	22.46	13.68
6	70.62	21.63
7	71.42	22.43
8	74.42	27.62
9	77.42	32.82
10	80.42	38.02
11	82.72	42.00
12	85.90	47.09
13	88.97	52.00

*** 1.725 ***

Failure Surface Specified By 14 Coordinate Points

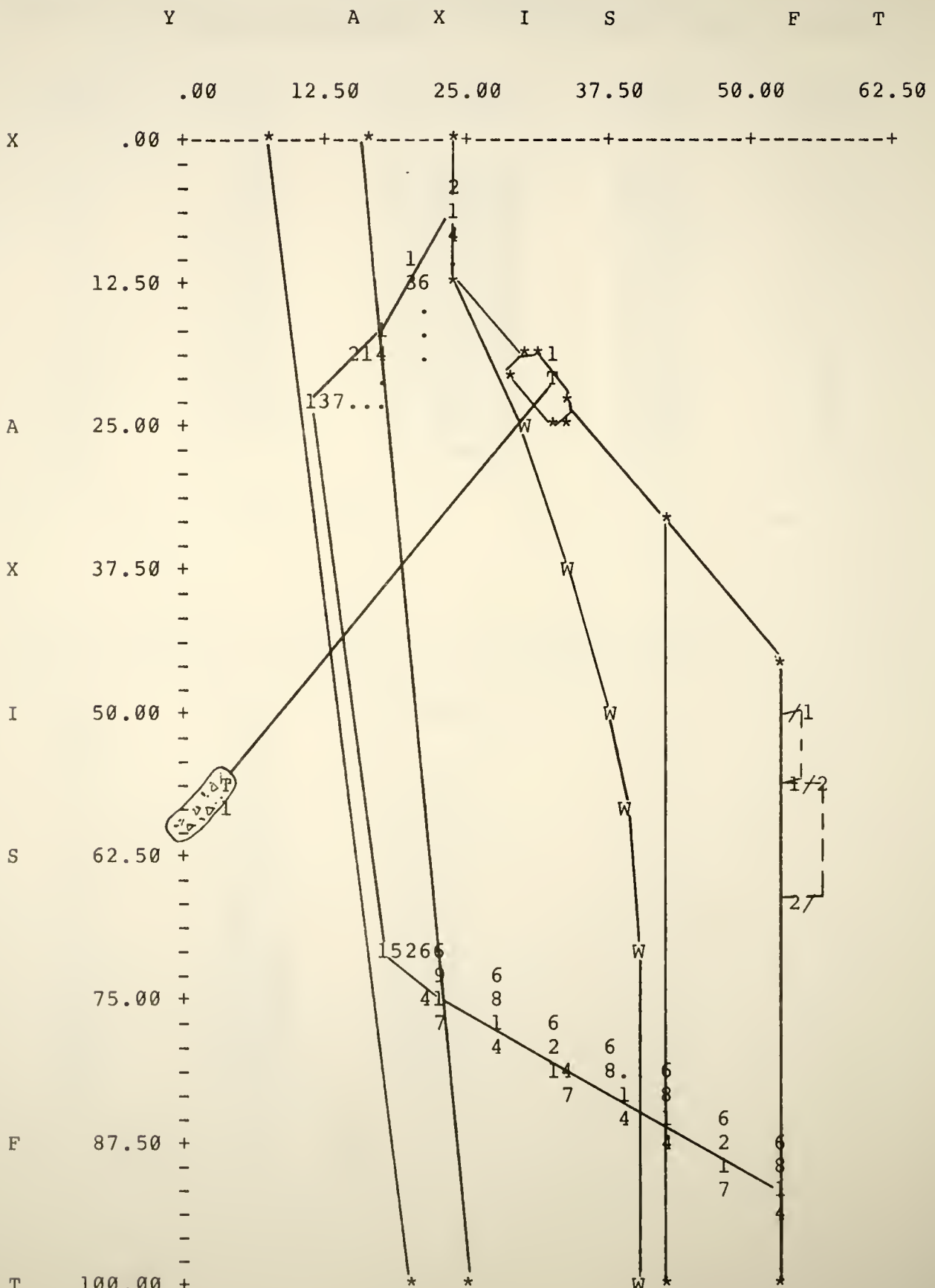
Point No.	X-Surf (ft)	Y-Surf (ft)
1	7.70	24.00
2	8.26	23.68
3	13.45	20.68
4	18.65	17.68
5	18.71	17.61
6	22.96	13.37
7	70.17	19.19
8	73.60	22.62
9	76.60	27.82
10	79.60	33.02
11	82.60	38.21
12	84.79	42.00
13	87.97	47.09
14	91.04	52.00

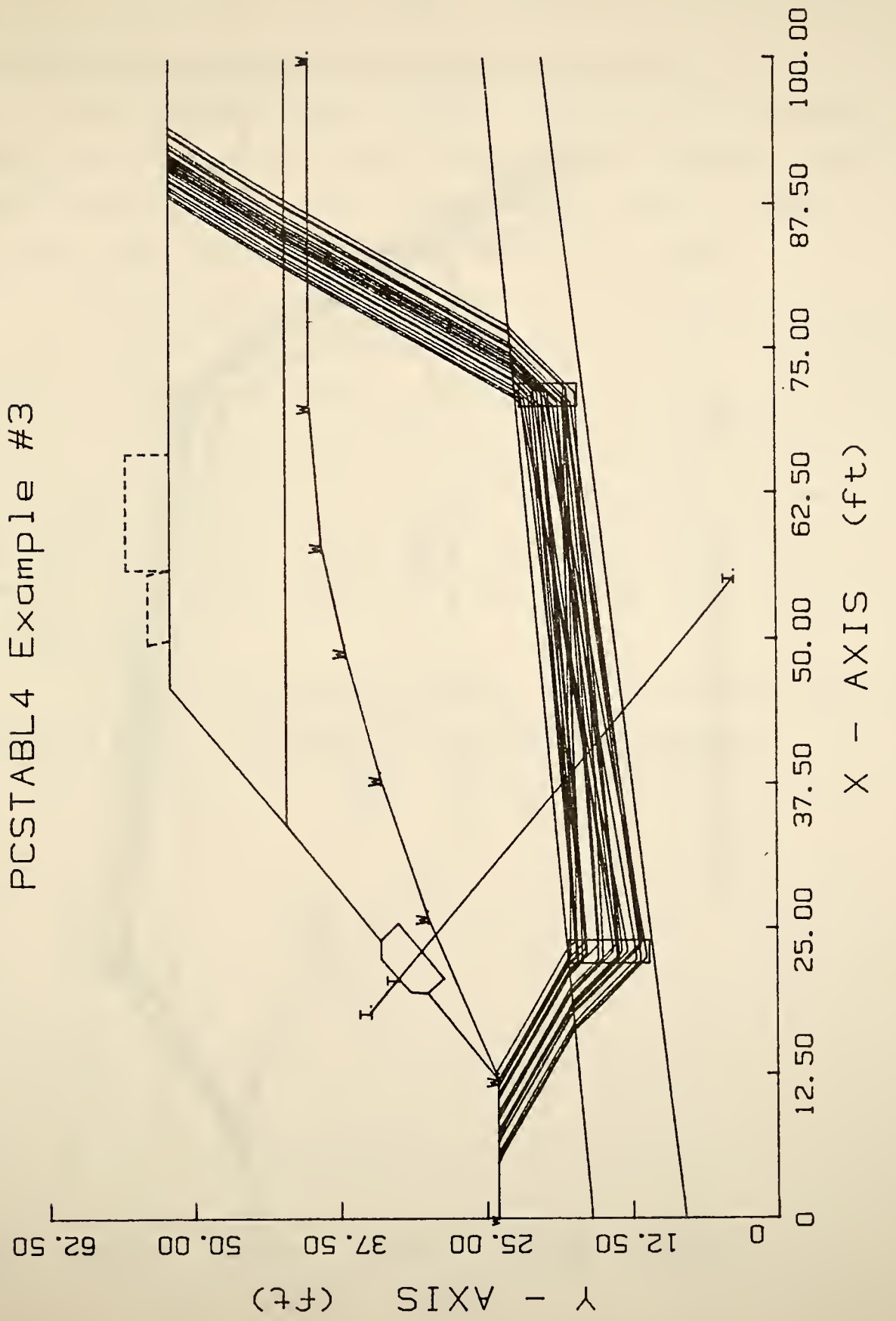
*** 1.729 ***

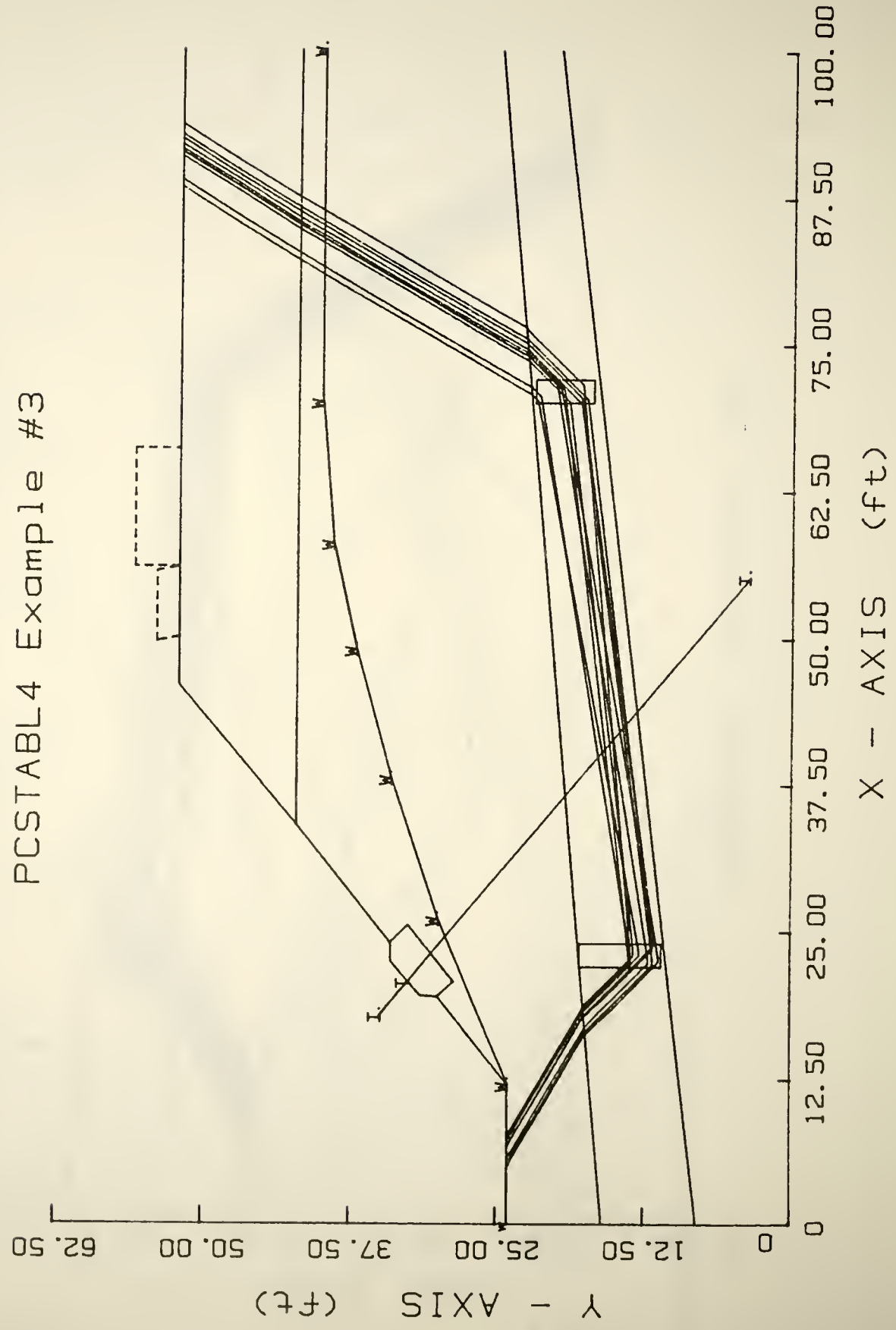
Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	7.42	24.00
2	8.01	23.66
3	13.21	20.66
4	18.40	17.66
5	22.26	13.80
6	71.20	19.61
7	74.28	22.68
8	77.28	27.88
9	80.28	33.08
10	83.28	38.27
11	85.43	42.00
12	88.61	47.09
13	91.68	52.00

*** 1.756 ***


Y A X I S F T
.00
12.50
25.00
37.50
50.00
62.50
X .00
12.50
A 25.00
X 37.50
I 50.00
S 62.50
75.00
F 87.50
T 100.00


PCSTABL4 Example #3
X - AXIS (ft)
0
12.50
25.00
37.50
50.00
62.50
75.00
87.50
100.00
Y - AXIS (ft)
62.50
50.00
37.50
25.00
12.50
0


PCSTABL4 Example #3
Y - AXIS (ft)
62.50
50.00
37.50
25.00
12.50
0
X - AXIS (ft)
0
12.50
25.00
37.50
50.00
62.50
75.00
87.50
100.00

APPENDIX A: Variable And Subroutine Definitions

This appendix contains the variable and subroutine definitions that were removed from the PCSTABL4 FORTRAN source code listing. They are provided here to assist the user in understanding the FORTRAN source code of the program.

The listing of the source code is not provided in this manual, however if the user wishes, he or she may print out the listing from the FORTRAN source code files on DISK #2 and DISK #3, or contact Purdue University for a complete listing. Since many modifications and improvements have been made to STABL over the years, including those made to implement the program on the microcomputer, the source code listing has been renumbered.

A list of non-FORTRAN statements used in the 8087 version (version 1.87) is included at the end of this appendix.

a	Array containing the real one digit numbers.
a1	Array used in factor of safety calculation.
a12	Intercept of line through points 1 and 2.
a2	Array used in factor of safety calculation.
a3	Array used in factor of safety calculation.
a34	Intercept of line through points 3 and 4.
a4	Term used in factor of safety calculation.
a5	Term used in factor of safety calculation.
a6	Term used in factor of safety calculation.
ab	Y intercept of the perpendicular bisector of a line segment whose end points are the left termination limit at the ground surface and the right end point of the initial line segment of a circular trial failure surface.
abs	Standard function which determines the absolute value of a number.
ae	Y intercept of the perpendicular bisector of a line segment whose end points are the right termination limit at the ground surface and the right end point of the initial line segment of a circular trial failure surface.
ai	Intercept of boundary (i).
aj	Intercept of boundary (j).
alpha	Array containing values of the angles of the base of each slice.
alpha1	Array containing angles used to calculate the normal and tangential components of the tieback forces at the base of each slice.
ang1	Unmodified counterclockwise direction limit, for all initiation points, at which initial line segment of a trial failure surface may project.
ang2	Unmodified clockwise direction limit, for all initiation points, at which initial line segment of a trial failure surface may project.
anglmt	The minimum inclination allowed for a generated trial failure surface.

angs1 Counterclockwise direction limit, which may be modified during generation of surfaces from a particular initiation point, at which initial line segment of a trial failure surface may project.

angs2 Clockwise direction limit, which may be modified during generation of surfaces from a particular initiation point, at which initial line segment of a trial failure surface may project.

aniso Subroutine that reads, stores, and prints out directional strength parameters of anisotropic soil types.

at Area of slice subsection above freewater surface.

atan Standard function that calculates the arctangent of an angle.

axis An array containing the x axis label.

b Slope of line defining ground surface where it is intersected by the trial failure surface.

b12 Slope of line through points 1 and 2.

b34 Slope of line through points 3 and 4.

bb Slope of the perpendicular bisector of a line segment whose end points are the left termination limit at the ground surface and the right end point of the initial line segment of a circular trial failure surface.

be Slope of the perpendicular bisector of a line segment whose end points are the right termination limit at the ground surface and the right end point of the initial line segment of a circular trial failure surface.

beta Array containing values of the angle of the top of each slice.

bgrid Slope of a sliding block box's centerline.

bi Slope of boundary (i).

bj Slope of boundary (j).

blksuf Subroutine which generates individual pseudo-random surfaces of sliding block shape.

block Entry of subroutine random which reads search parameters and directs random search for the critical sliding block surface.

block2 Subroutine which generates individual pseudo-random surfaces of sliding block shape with active and passive zones generated according to the rankine theory.

bn Array containing the boundary numbers corresponding to the point of application of each tieback load.

bnds An array containing the coordinates of the end points defining the ground surface and subsurface boundaries.

bot Denominator of factor of safety expression.

bpt Position on ground surface which each trial surface must exceed when it terminates.

c Array containing isotropic values of the mohr-coulomb cohesion for each soil type.

ca Cosine of angle alpha.

cavt Cavitation pressure.

cb Cosine of angle beta.

cblk Control code which indicates whether block or block2 surface is to generated.

cd Cosine of angle delt.

corr Array containing correction factors to make the sum of the tieback forces on trial failure surface equal to the applied load for each tieback specified.

cos Standard function that calculates the cosine of an angle.

cplt Control code which controls construction of geometry print character array.

csa Array containing values of mohr-coulomb cohesion for each specified direction range of each anisotropic soil type.

cslice Cohesion at the base of a slice.

cu Array containing values of pore pressue constants for each soil type.

date	Character variable that stores the date.
delt	Array containing values of inclination of the boundary load for each slice.
delta	Array containing values of load direction for each boundary load specified.
denoi	Denominator for slope computation of boundary (i).
denoj	Denominator for slope computation of boundary (j).
denom	Denominator of expression checked as a precaution of being zero.
descr	Array containing the second line of the problem description.
dev	Array containing values of angles between the horizontal plane and the line between the point of application of a tieback and the center of the base of a slice for each slice.
direc	Array containing values defining the counterclockwise limit of each direction range of each anisotropic soil type.
dist	Array containing values of the distance between the point of application of a tieback and the center of the base of a slice.
dtheta	Change in direction between two adjacent line segments of a circular trial failure surface.
dummy	Dummy variable used in call of subroutine reader when an integer is to be read.
dx	Array containing values of the width of each slice.
dy	Vertical component of a scaled boundary load.
end	Last position on the ground surface at which trial surfaces initiate.
ept	Position on ground surface which each trial surface must not exceed while being generated.
equake	Subroutine that reads in, stores, and prints out earthquake data.
error	Character variable representing current error code.

execut Subroutine that directs calculation of the factor of safety for a specified failure surface.

f Critical local factor of safety used to detect a negative normal force acting on a slice.

fl Largest critical local factor of safety used to detect a negative normal force acting on a slice.

factr Subroutine which calculates the factor of safety.

flag Flag used to control calculation of the y coordinate of the base of each slice.

float Standard function that converts an integer number to a real number.

fnamein Character variable which stores the name of the input file.

fnameout Character variable which stores the name of the output file.

fnew New factor of safety used during iterative process.

fold Old factor of safety used during iterative process.

frtyfv 45 degrees in radians.

fs Factor of safety.

fss Array containing values of the factor of safety for the ten most critical trial surfaces of those generated and examined.

gamma Array containing values of the total unit weight for each soil type.

gsat Array containing values of the saturated unit weight for each soil type.

hghteq Array of the values of the hight of the centroid of the horizontal earthquake forces above the base of each slice.

hight Array containing the heights of the slices.

hp Control code which controls construction of output file for plotting with aplotting device.

i Index variable for array subscripting.

ia Array containing the integer one digit numbers.

iangl Control code signals whether trial surface initiation angles have been specified or not.

iblk Control code which activates generation of a sliding block surface.

iblk2 Control code which activates generation of a sliding block surface with rankine active and passive wedges.

icirc Control code which directs generation of circular or irregular surfaces.

idummy Dummy variable used in call of subroutine reader when a real number is to be read.

iexit Control code which terminates execution, if data is inconsistant with the requirements of the program.

ifix Standard function that converts a real number to a integer number.

ii Index variable for array subscripting.

ij Index variable for array subscripting.

ilimit Control code which activates portions of the program affected by searching limits established by subroutine limits.

inclin Array containing values of tieback inclination as measured clockwise from the horizontal plane for each tieback load specified.

incre Spacing between the trial surface initiation points.

ints Control code which signals whether an intersection has occurred or not.

intsc2 Subroutine which determines whether or not a line segment and a vertical line intersect and calculates the coordinates of the intersection.

intsc3 Subroutine which determines whether or not a line segment and a horizontal line intersect and calculates the coordinates of the intersection.

intsct Subroutine which determines whether or not two line segments intersect and calculates the coordinates of the intersection.

iplot Control code which controls translation of axes for plotted output.

iprof	Control code used for checking profil sequence requirement.
ir	Control code which determines whether a number read is to be handled as a real number or as an integer.
iread	Control code which prompts reading a new line of data.
isearc	Control code which activates portions of the program affected by the searching subroutine random.
isoil	Control code which indicates definition of isotropic soil data.
isort	Control code used to direct sorting of trial surfaces.
istr	Control code which activates portions of the program handling anisotropic strength condition.
isum	Integer number that is assembled.
isurc	Control code which activates portions of the program handling the surcharge loads specified by subroutine loads.
isurf	Control code which indicates definition of specified trial failure surface.
ities	Control code which activates portions of the program handling the tieback anchor loads specified by subroutine ties.
itn	Variable used to temporary store the value of an index variable used for array subscripting.
itp	Array containing soil type indices for each boundary.
itpa	Array containing the indices of anisotropic soil types.
iwat	Control code which activates portions of the program handling the water surface specified by subroutine water.
ix	Horizontal position of point within plot array.
ixx	Stores value of ix.
iy	Vertical position of point within plot array.
iyy	Stores value of iy.

j	Index variable for array subscripting.
j2	Value of j rounded down to an even integer.
jab	Subscript of the last profile boundary used to check for intersection with the last linesegment generated on the active portion of the trial failure surface.
jb	Subscript of last boundary, defining the ground surface, to be used for determining whether a sliding block box lies entirely below the ground surface.
ji	Subscript of last boundary, defining the ground surface, to be used for determining the y coordinate of the intersection of the left termination limit with the ground surface.
jj	Subscript of last ground surface boundary used for calculation of the y coordinate of an initiation point.
jp	Subscript of the last profile boundary used to check for intersection with vertical line through the last point generated on the trial failure surface.
jpb	Subscript of the last profile boundary used to check for intersection with the last linesegment generated on the passive portion of the trial failure surface.
js	Subscript of last ground surface boundary used to determine the y coordinate of the beginning or end of a surcharge boundary load.
jt	Subscript of the last ground surface boundary used to check for an intersection of a trial failure surface with the defined ground surface.
jtn	Variable used to temporarily store the value of an index variable used for array subscripting.
jtt	Subscript of the last ground surface boundary used to check for an intersection of a redefined trial failure surface with the ground surface.
jw	Array containing the subscript of last point defining each piezometric surface, used to determine the intersection of the centerline of a slice with the piezometric surface.
jww	Stores value of jw.
k	Index variable for array subscripting.

k1	k-1
k2	Value of k rounded down to an even integer.
kcoef	Horizontal earthquake coefficient.
kd	Decimal location.
kdl	kd - 1
keyw	Character array of keywords used to compare with commands directing control of the program by user.
kf	Location of last digit in number.
ki	Location of first digit in number.
kk	Index variable for array subscripting.
l	Index variable for array subscripting.
lb	Y coordinate of slice base.
length	Array containing values of the length of each tieback specified.
limit	Array containing the coordinates of the end points defining each boundary used to confine the extent of searching by subroutine random.
limits	Subroutine that reads in, stores, and prints out the limits which bound the area to be searched with subroutine random.
load	Array containing values of uniform load intensity for each boundary load specified.
loads	Subroutine that reads in, checks, stores, and prints out boundary loading data.
m	Array containing the individual characters read from a line of data.
maxl	Maximum intensity of the boundary loads specified.
maxtl	Maximum intensity of the equivalent line loads for all tiebacks specified.
maxx	Maximum x coordinate of any geometry point.
maxy	Maximum y coordinate of any geometry point.

mb	Control code which indicates modified Bishop factor of safety calculation (if mb=1).
mkeyw	Character variable representing the command last read in.
n	Array containing alpha-numeric characters used for comparisons.
name	Character variable which stores the name of the person running the program.
nbnd	Total number of profile boundaries.
nbndl	nbnd - 1
ncha	Number of soil type changes.
nd	Do loop terminator.
ndirec	Array containing the number of direction ranges for each anisotropic soil type.
ngrid	Number of boxes specified.
nipt	Number of initiation points.
nlim	Number read as number of surface generation limit boundaries specified.
nlimit	Number of surface generation limit boundaries.
nlmt	Number of surface generation limit boundaries which deflect generated surfaces upward.
nn	Variable used to temporary store an array variable for a do statement.
np	Array containing number of piezometric surface for each soil type.
npi	Number read as number of piezometric surfaces defined.
npiez	Number of points defining the water surface.
npz	Number of piezometric surfaces defined.
nr	Total number of rejections while attempting to generate a trial failure surface.
nrr	Number of rejections while attempting to generate a circular surface from the second line segment when

	conflict occures with restrictions on minimum elevation and overturning slip surface.
ns	Number of points defining the last surface generated.
nsa	Number read as number of soil types having anisotropic strength properties.
nsal	Number of soil types having anisotropic strength properties.
nslice	Number of slices that sliding mass is divided into.
nsoi	Number read as number of soil types.
nsoil	Number of soil types specified.
nsuc	Number read as number of boundary loads specified.
nsurc	Number of boundary loads specified.
nsurf	Number of points defining a trial failure surface.
nsurfs	Array containing values of the number of points defining each of the ten most critical trial surfaces.
ntie	Number read as number of tieback anchor loads specified.
nties	Number of tieback anchor loads specified.
ntop	Number of ground surface boundaries.
ntopl	ntop + 1
ntria	Total number of trial failure surfaces generated.
ntrial	Number of trial surfaces generated from each starting point.
p	Array containing values of the boundary load applied to each slice.
perpen	90 degrees in radians.
phi	Array containing isotropic values of the mohr-coulomb angle of internal friction for each soil type.
phia	Array containing values of the mohr-coulomb angle of internal friction for each specified direction range of each anisotropic soil type.
pi	Pi.

pl	A scaled boundary load.
pload	Array containing the values of the tieback anchor point loads applied to the ground surface for each tieback anchor specified.
plotfile	Character variable which stores the name of the output file used for plotting with a plotting device.
plotin	Subroutine which writes control codes and coordinates to the plotted output file.
plt	Array containing the character plot matrix.
pltn	Subroutine which sets up the axes and axis lables for the print character plot.
plttr	Character array containing plotter control codes which are written to plotted output file for directing control of plotter.
postn	Subroutine which determines the position of a scaled coordinate point within the character plot array.
prad	Array containing values of the unresolved tieback force on the base of each slice.
profil	Subroutine that reads in, checks, stores, and prints out profile geometry data.
psum	Array containing values of the sum of the tieback forces on the base of each slice over the whole trail failure surface for the current tieback load.
quit	Subroutine that displays a termination message, and terminates execution of the program.
r	Variable containing a pseudo-random number.
rad5	5 degrees in radians.
radius	Distance between the coordinate points and the center of the simplified Bishop limit equilibrium surface (mb=1).
random	Subroutine that directs random search for the critical irregular or circular surface.
ranf	Function subprogram that generates a pseudo-random number that has a uniform probability of having any value ranging from zero to one.

ransuf Subroutine which generates individual pseudo-random surfaces of a circular and irregular nature.

rb Radius of a circle containing the left termination limit at the ground surface and both end points of the initial line segment generated for a circular trial failure surface.

rbx X coordinate of the center of a circle containing the left termination limit at the ground surface and both end points of the initial line segment generated for a circular trial failure surface.

rby Y coordinate of the center of a circle containing the left termination limit at the ground surface and both end points of the initial line segment generated for a circular trial failure surface.

rd Factor for conversion of degrees to radians.

re Radius of a circle containing the right termination limit at the ground surface and both end points of the initial line segment generated for a circular trial failure surface.

reader Subroutine that reads integer or real data in free form format.

rex X coordinate of the center of a circle containing the right termination limit at the ground surface and both end points of the initial line segment generated for a circular trial failure surface.

rey Y coordinate of the center of a circle containing the right termination limit at the ground surface and both end points of the initial line segment generated for a circular trial failure surface.

ru Array containing values of the pore pressure parameter for each soil type.

sa Sine of angle alpha.

sb Sine of angle beta.

scaler Subroutine which determines the scale for plotting.

scl Array which contains the tick mark lables.

scle Scale used for plotting.

sd Sine of angle delt.

sin	Standard function that calculates the sine of an angle.
slices	Subroutine which divides sliding mass into slices.
slope	Slope in radians of line defining the ground surface where a trial surface initiates.
slp	Slope of line extending from first point on ground surface to either of the bottom corners of the first box specified for a sliding block search.
slpb	Slope of a line segment whose end points are the left termination limit at the ground surface and the right end point of the initial line segment of a circular trial failure surface.
slpe	Slope of a line segment whose end points are the right termination limit at the ground surface and the right end point of the initial line segment of a circular trial failure surface.
sltp	Array containing indices of the soil type at the base of each slice.
soil	Subroutine that reads in, stores, and prints out isotropic soil parameters.
soil	Array containing indices of soil type of each subsection within a slice (in sub. wght).
soiltp	Variable containing soil type at the base of a slice.
soilwt	Subroutine that calculates the total weight of a slice subsection.
sort	Subroutine that sorts ten trial failure surfaces by magnitude of factor of safety.
space	Array containing the values of the horizontal spacing between tiebacks for each row of tieback anchors specified.
sqrt	Standard function that calculates the square root of a number.
ssign	Variable used to handle the sign of the number being assembled.
st	Soil type of subsection.
start	First position on the ground surface at which trial surfaces initiate.

sum	Real number that is assembled.
sumb	Denominator of first derivative of the factor of safety expression.
sumt	Numerator of first derivative of the factor of safety expression.
surc	Array containing x coordinates of the end points defining the extent of loading.
surf	Array containing the x and y coordinates of points defining the trial failure surface.
surfac	Subroutine that reads in, checks, stores, and prints out data defining an individual trial failure surface.
surfs	Array containing sets of coordinate points defining each of the ten most critical trial surfaces.
switch	Array used to temporarily store the contents of array surf for reordering.
symb	Array which contains the characters that are used for plotting.
symbol	External subroutine that activates the plotting pen to plot characters or on-center symbols.
ta	Tangent of angle alpha.
tal	Integer variable storing the number of trial surfaces generated in a search, used by the external subroutine number.
tan	Standard function that calculates tangens of an angle.
thet	Angle at which a line segment of a circular surface intersected a surface generation boundary.
theta	Direction of last line segment defining the trial surface.
theta1	Angle spread within which the next line segment of the generating trial surface may project.
theta2	Limiting angle in clockwise direction at which next line segment may project.

thetab Maximum change in direction allowed between adjacent line segments of a circular trial failure surface with a particular initial line segment.

thetae Minimum change in direction allowed between adjacent line segments of a circular trial failure surface with a particular initial line segment.

thetal Minimum inclination allowed for a particular line segment of an irregular trial failure surface.

thetas Inclination of the initial line segment of a trial failure surface.

thetau Maximum inclination allowed for a particular line segment of an irregular trial failure surface.

ties Subroutine that reads in, checks, stores, and prints out tieback anchor load data.

time Character variable which stores the time.

title Array containing the first line of the problem description.

tl A scaled equivalent line load for a given tieback.

tload Array containing values of equivalent horizontal line loads for each tieback anchor specified assuming a uniform distribution of load to the ground surface between tiebacks.

tnorm Array containing values of the total tieback load acting normal to the base of each slice for all tieback loads specified.

tol Tolerance constant to account for machine rounding.

tp Tangent of angle phi.

trans Subroutine which transfers the equivalent line load for each tieback to the base of each slice using Flamants's formulas.

tsurf Length of line segments defining trial surfaces.

tt Tangent of the inclination of the initial line segment of a trial failure surface.

ttan Array containing values of the total tieback load acting tangent to the base of each slice for all tieback loads specified.

ttheta Array containing values of angles between the line of action of a tieback and the line between the point of application of a tieback and the center of the base of a slice for each slice.

ualpha Array containing values of the hydrostatic force acting at the base of each slice.

ub Y coordinate of top of slice.

ubeta Array containing values of the hydrostatic force acting at the top of each slice.

uwat Unit weight of water. If Ø. is specified, 62.4 pcf is assumed.

vkcoef Vertical earthquake coefficient.

w Scaled width of a box for for sliding block search.

water Subroutine that reads in and prints out the water surface data.

weight Subroutine which calculates the total weight of each slice.

width Array containing the values of the width of each box.

wt Weight of a slice subsection.

wtheq The product of the weight of a slice and the distance between its base and the centroid of its horizontal earthquake force.

wtt Array containing values of the weight of each slice.

x Array containing the x coordinates of the center of the base of each slice.

x1 X coordinate of the projected intersection of two boundary line segments.

x2 X coordinate of second point.

x3 X coordinate of third point.

x4 X coordinate of fourth point.

xb X coordinate of the midpoint of a line segment whose end points are the left termination limit at the ground surface and the right end point of the initial line segment of a circular trial failure surface.

xcntr	X coordinate of the center of a circular limit equilibrium surface.
xe	X coordinate of the midpoint of a line segment whose end points are the right termination limit at the ground surface and the right end point of the initial line segment of a circular trial failure surface.
xend	Array containing values of the calculated x coordinate of the end of each tieback specified.
xhalf2	X coordinate of the midpoint of the second segment on the limit equilibrium surface.
xint	X coordinate of intersection of two line segments.
xl	Array containing values of the x coordinate of the left end of each box centerline.
xm	xl - tol
xp	xl + tol
xpiez	Array containing x coordinates of points defining water surface.
xr	Array containing values of the x coordinate of the right end of each box centerline.
xtie	Array containing calculated values of the x coordinate of the point of application on the ground surface of each tieback anchor load specified.
xx	X coordinate of point to be scaled.
y	Y coordinate of intersection of two line segments.
yl	Y coordinate of the projected intersection of two boundary line segments.
yl	Y coordinate of first point.
y2	Y coordinate of second point.
y3	Y coordinate of third point.
y4	Y coordinate of fourth point.
yb	Array containing values of the y coordinate of the base of each slice.
ybpt	Y coordinate of left termination limit at the ground surface.

ycntr Y coordinate of the center of the limit equilibrium surface.

ye Y coordinate of the midpoint of a line segment whose end points are the right termination limit at the ground surface and the right end point of the initial line segment of a circular trial failure surface.

yend Array containing values of the calculated y coordinate of the end of each tieback specified.

yept Y coordinate of right termination limit at the ground surface.

ygl Y coordinate of point on ground surface directly above the left end of a sliding block box.

ygr Y coordinate of point on ground surface directly above the right end of a sliding block box.

yhalf2 Y coordinate of the midpoint of the second segment on the limit equilibrium surface.

yi Array containing the y coordinates of intermediate points dividing a slice into subsections.

yint Y coordinate of intersection of two line segments.

yl Array containing values of the y coordinate of the left end of each box centerline.

yll Left top corner of a sliding block box.

ymax End point of surface generation boundary with the maximum y coordinate.

ymin Lowest depth to which a trial surface may extend.

ypiez Array containing y coordinates of points defining water surface.

yr Array containing values of the y coordinate of the right end of each box centerline.

yrr Right top corner of a sliding block box.

ysurc Array containing the calculated y coordinates of the ends of the boundary loads on the ground surface.

yt Y coordinate of the top of a slice.

ytie Array containing inputted values of the y coordinate of the point of application on the ground surface of each tieback anchor load specified.

yw Array containing y coordinate of the piezometric surface for each soil type of a slice.

yy Y coordinate of point to be scaled.

NON-FORTRAN STATEMENTS:

$NOFLOATCALLS A Microsoft FORTRAN Metacommand used during compilation which directs the compiler to create an executable program which optimizes use of the Intel 8087 Math Co-Processor during execution of the program.

COVER DESIGN BY ALDO GIORGINI