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PLANAR : a QuickBasic program for planar stability analysis on an IBM-compatible micro-computer

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Abstract

The program described is used for calculating the Factor of Safety for planar slope failure.

INTRODUCTION

Planar slip circle analysis is a simplistic approximation of the real world and does not take into account the variability of natural materials. For this reason an option is provided in the program which allows calculations to be made over a range of values for any one input parameter. The user must make value judgements not only on the validity of the input data, but also on the applicability of the results.

When the micro-computer is turned on, a menu is displayed from which selections can be made by using the up and down arrow keys to highlight an option, or alternatively by typing the number corresponding to the option. The planar program is accessed by selecting in sequence **Modelling programs**, **Stability analysis** and **Planar stability analysis** from the menu displays. A full listing of the program is given in Appendix A.

DATA INPUT

Once the program has been accessed, the user is initially requested to provide a site identification. This is used as a header for print-outs and to identify data saved to diskettes. A short descriptive identification of the site should be typed, but do not use commas. The return or enter key is pressed after typing the site identification.

The user is then given the option to make calculations with or without cohesion. If a Y(es) response is given, data values for effective cohesion, density of the material overlying the failure plane, the depth to the failure plane, the slope angle, the effective angle of internal friction on the failure plane, and the pore pressure ratio are requested. If a N(o) response is given, data values for the slope angle, effective angle of internal friction on the failure plane, and the pore pressure ratio are requested.

CALCULATIONS

When data input is complete, the Factor of Safety (Schuster and Krizek, 1978) is calculated using the expression:

$$F = \frac{c'}{\gamma d} \sec\alpha \operatorname{cosec}\alpha + \frac{\tan\phi'}{\tan\gamma}(1 - r_u \sec^2\alpha)$$

where c' = effective cohesion
γ = density of material above failure plane
d = depth to failure plane
α = angle of slope
ϕ' = effective angle of internal friction
r_u = pore pressure ratio

OPTIONS

An options menu (fig. 1) is displayed immediately after the Factor of Safety has been calculated and displayed. An option is selected by typing the first letter of its name. The options available are:

Alter data: used to change the value of a single input parameter and recalculate the Factor of Safety. When this option is selected a further menu (fig. 2) will request which input parameter is to be changed. The parameter is selected by typing the first letter of its name. The existing value is then erased from the screen and the user requested for a new value. When this has been entered, a new Factor of Safety will be calculated, displayed, and the options menu re-displayed.

Begin again: is used to re-start the program at the site identification request. This allows several different situations to be identified and processed in the one session.

Exit program: is used to terminate the program. The menu system will then be re-displayed at the point where the program was selected. To return to a previous menu, press the ESC key.

Print data: is used to send the site identification, data input values and the results of the calculation to the line printer which must be switched on beforehand. A typical print-out is presented as Figure 3.

Save data: is used to store the site identification, data input values, and the results of the calculation to a diskette. When this option is first used, or after the "begin again" option has been selected, the file specification of the data file is requested (fig. 4). Default values are displayed and these are accepted by pressing the return or enter key. New values may be typed over the defaults. A new value is accepted by pressing the return or enter key. The file specification is briefly displayed before the data is written to the diskette (in ASCII format). If the file already exists, the data are appended to the end of the file. A typical print-out of the data file is presented as Figure 5.

Range of values: is used to calculate the Factor of Safety for a single parameter over a range of values. When this option is selected, a further menu (fig. 6) displays the

parameters for which range calculations are available. Select the parameter required by typing the first letter of its name. The start and end values for the parameter are requested, together with the increment or step value between successive calculations for the parameter (fig. 6). Once these values have been entered the program automatically calculates the Factor of Safety, prints the details to the line printer, and saves them to diskette. If a file specification has not been given previously, it will be requested as for the case when the save data option is selected.

REFERENCE

SCHUSTER, R. L.; KRIZEK, R. J. (ed.). 1978. *Landslides: analysis and control.* National Academy of Sciences : Washington D.C. [Special Report Transportation Research Board, National Research Council, 176].

[12 July 1989]

STABILITY ANALYSIS: PLANAR FAILURE

Site Identification : Example with cohesion

with COHESION (Y/N) : Y

Cohesion (kPa)	=	3.1
Density (kN/cub m)	=	18.00
Failure plane Depth (m)	=	3.00
Slope angle (degrees)	=	16.0
Angle of friction (degrees)	=	16.0
Pore pressure ratio (Ru)	=	0.00
Factor of Safety	=	1.22

OPTIONS:

Alter data	Print data
Begin again	Save data
Exit program	Range of values

Enter A B E P S or R :

Figure 1a. *Data input to program PLANAR, showing an example with cohesion. The options menu is also shown.*

STABILITY ANALYSIS: PLANAR FAILURE

Site Identification : Example without cohesion

with COHESION (Y/N) : N

Slope angle (degrees)	=	16.0
Angle of friction (degrees)	=	16.0
Pore pressure ratio (Ru)	=	0.00
Factor of Safety	=	1.00

OPTIONS:

Alter data	Print data
Begin again	Save data
Exit program	Range of values

Enter A B E P S or R :

Figure 1b. *Data input to program PLANAR, showing an example without cohesion. The options menu is also shown.*

STABILITY ANALYSIS: PLANAR FAILURE

Site Identification : Example with cohesion

with COHESION (Y/N) : Y

Cohesion (kPa)	=	3.1
Density (kN/cub m)	=	18.00
Failure plane Depth (m)	=	3.00
Slope angle (degrees)	=	16.0
Angle of friction (degrees)	=	16.0
Pore pressure ratio (Ru)	=	0.00
Factor of Safety	=	1.22

CHANGE: Slope angle Cohesion
Angle of friction Density
Pore press ratio Failure plane

Enter S A P C D or F :

Figure 2a. *Screen dump from program PLANAR, showing the menu available to alter data for an example with cohesion.*

STABILITY ANALYSIS: PLANAR FAILURE

Site Identification : Example without cohesion

with COHESION (Y/N) : N

Slope angle (degrees)	=	16.0
Angle of friction (degrees)	=	16.0
Pore pressure ratio (Ru)	=	0.00
Factor of Safety	=	1.00

CHANGE: Slope angle
Angle of friction
Pore press ratio

Enter S A or P :

Figure 2b. *Screen dump from program PLANAR, showing the menu available to alter data for an example without cohesion.*

Example with cohesion

Slope Angle (degrees)	Friction Angle (degrees)	Pore Press Ratio	Cohesion (kPa)	Density (kN/cub m)	Failure Plane (m)	Factor of Safety
16.0	16.0	0.00	3.1	18.0	3.0	1.22
16.0	16.0	0.10	3.1	18.0	3.0	1.11
16.0	16.0	0.20	3.1	18.0	3.0	1.00
16.0	16.0	0.30	3.1	18.0	3.0	0.89
16.0	16.0	0.40	3.1	18.0	3.0	0.78
16.0	16.0	0.50	3.1	18.0	3.0	0.68

Figure 3a. *A typical print-out from program PLANAR for a case with cohesion.*

Example without cohesion

Slope Angle (degrees)	Friction Angle (degrees)	Pore Press Ratio	Cohesion (kPa)	Density (kN/cub m)	Failure Plane (m)	Factor of Safety
16.0	16.0	0.00				1.00
16.0	16.0	0.10				0.89
16.0	16.0	0.20				0.78
16.0	16.0	0.30				0.68
16.0	16.0	0.40				0.57
16.0	16.0	0.50				0.46

Figure 3b. *A typical print-out from program PLANAR for a case without cohesion.*

Provide disk drive A:
Path name \
File-name PLANAR
Extension DAT

File specification is...A:\PLANAR.DAT

Figure 4. *Screen dump from program PLANAR showing details of the file specification to which data is saved.*

Example with cohesion

Slope Angle (deg)	Friction Angle (deg)	Pore Press Ratio	Cohesion (kPa)	Density (kN/c m)	Failure Plane (m)	Factor of Safety
16.0,	16.0,	0.00,	3.1,	18.0,	3.0,	1.22
16.0,	16.0,	0.10,	3.1,	18.0,	3.0,	1.11
16.0,	16.0,	0.20,	3.1,	18.0,	3.0,	1.00
16.0,	16.0,	0.30,	3.1,	18.0,	3.0,	0.89
16.0,	16.0,	0.40,	3.1,	18.0,	3.0,	0.78
16.0,	16.0,	0.50,	3.1,	18.0,	3.0,	0.68

Figure 5a. *Print-out of data file from program PLANAR for an example with cohesion.*

Example without cohesion

Slope Angle (deg)	Friction Angle (deg)	Pore Press Ratio	Cohesion (kPa)	Density (kN/c m)	Failure Plane (m)	Factor of Safety
16.0,	16.0,	0.00,	0,	0,	0,	1.00
16.0,	16.0,	0.10,	0,	0,	0,	0.89
16.0,	16.0,	0.20,	0,	0,	0,	0.78
16.0,	16.0,	0.30,	0,	0,	0,	0.68
16.0,	16.0,	0.40,	0,	0,	0,	0.57
16.0,	16.0,	0.50,	0,	0,	0,	0.46

Figure 5b. *Print-out of data file from program PLANAR for an example without cohesion. N.B. The columns headed Cohesion, Density and Failure Plane have been filled with a zero value to facilitate the import of the file to Lotus 1-2-3 where graphing functions are available.*

STABILITY ANALYSIS: PLANAR FAILURE

Site Identification : Example with cohesion

with COHESION (Y/N) : Y

Cohesion (kPa)	=	3.1
Density (kN/cub m)	=	18.00
Failure plane Depth (m)	=	3.00
Slope angle (degrees)	=	16.0
Angle of friction (degrees)	=	16.0
Pore pressure ratio (Ru)	=	0.00
Factor of Safety	=	1.22

RANGE: Slope angle / Cohesion
Angle of friction / Density
Pore press ratio / Failure plane

Start value of pore press ratio : 0
End value of pore press ratio : .5
Calculate in steps of : .1

Figure 6a. *Screen-dump from program PLANAR for a case with cohesion, showing the menu which allows the Factor of Safety to be calculated for a parameter over a range. The input data for the range is also shown.*

STABILITY ANALYSIS: PLANAR FAILURE

Site Identification : Example without cohesion

with COHESION (Y/N) : N

Slope angle (degrees)	=	16.0
Angle of friction (degrees)	=	16.0
Pore pressure ratio (Ru)	=	0.00
Factor of Safety	=	1.00

RANGE: Slope angle
Angle of friction
Pore press ratio

Start value of pore press ratio : 0
End value of pore press ratio : .5
Calculate in steps of : .1

Figure 6b. *Screen-dump from program PLANAR for a case without cohesion, showing the menu which allows the Factor of Safety to be calculated for a parameter over a range. The input data for the range is also shown.*

APPENDIX A

Listing of QuickBasic program PLANAR

```
'------------------------------ PLANAR.BAS ---------------------------------
'
'                          Planar stability analysis '
'                            written by B D Weldon '
'                          last revised 14th June 1989 '
'---------------------------------------------------------------------------

DECLARE SUB SetScene ()
DECLARE FUNCTION AlphaKey! (Row!, Col!, Fore!, Back!, AlphaPrompt$, Valid$)
DECLARE SUB DataRequired (Need$)
DECLARE FUNCTION GetData! (Dataprompt$, UsePrompt$, Row, Col)
DECLARE FUNCTION CalculateResults! ()
DECLARE SUB ShowResults ()
DECLARE SUB ShowMenu ()
DECLARE SUB EraseMenu ()
DECLARE SUB ShowDataMenu (DataMenuPrompt$)
DECLARE SUB PrintData ()
DECLARE SUB SaveData ()
DECLARE SUB RangeData ()
DECLARE SUB ShowRange ()
DECLARE FUNCTION GetFile$ (dmy$)
DECLARE FUNCTION GetString$ (Prompt$, Default$, Row!, Col!)

CONST ConFactor = 2 * 3.141593 / 360

DEF FNSec (X)
FNSec = 1 / COS(X * ConFactor)
END DEF

DEF FNCosec (X)
FNCosec = 1 / SIN(X * ConFactor)
END DEF

ExitNow = 1

DO

   BeginAgain = 1: DiskHeader = 0: Printheader = 0
   SetScene
   DataRequired (Need$)

   DO
       FactorOfSafety = CalculateResults
       ShowResults
       ShowMenu

   LOOP UNTIL BeginAgain < 0

LOOP UNTIL ExitNow < 0

PRINT : PRINT : PRINT "PROGRAM ENDED"

END

'================================ ALPHAKEY ==================================
'Display a prompt (AlphaPrompt$) at line (Row), column (Col) with foreground
'(Foreground) and background color (Background) and request a response
'(Response$) from the keyboard.  The response is checked against Valid$ and
'if invalid a tone is sounded. The request is re-issued until a valid
'response is given.  The position of the keystroke (Response) in the string
'Valid$ is returned.
'============================================================================
'
FUNCTION AlphaKey (Row, Col, Foreground, Background, AlphaPrompt$, Valid$)

DO
```

```
   LOCATE Row, Col, 1, 0, 7: COLOR Foreground, Background
   PRINT AlphaPrompt$;
   Response$ = UCASE$(INPUT$(1))
   LOCATE , , 1, 0: PRINT Response$
   Response = INSTR(Valid$, Response$)
   IF Response <1 THEN BEEP

LOOP UNTIL Response <> 0

AlphaKey = Response

END FUNCTION

'============================ CalculateResults ================================
'Calculates the Factor of Safety for the input given.  ConFactor converts
'degrees to radians which are required for the trignometric functions.
'==============================================================================
'                                                                             '
FUNCTION CalculateResults

SHARED CohesionYesNo, Cohesion, Density, Depth, Slope, Friction, PorePressure

IF CohesionYesNo = 1 THEN
   Term1 = (Cohesion / (Density * Depth)) * FNSec(Slope) * FNCosec(Slope)
ELSE
   Term1 = 0
END IF

Term2 = (TAN(ConFactor * Friction) / TAN(ConFactor * Slope))
Term3 = 1 - PorePressure * FNSec(Slope) * FNSec(Slope)
SafetyFactor = Term1 + Term2 * Term3
CalculateResults = SafetyFactor

END FUNCTION

'============================== DataRequired ==================================
'Obtains the necessary input data for the model.  The content of the string
'Need$ determines which input has been requested.
'==============================================================================
'
SUB DataRequired (Need$)

SHARED Cohesion, Density, Depth, Slope, Friction, PorePressure

Passes = LEN(Need$)

FOR I = 1 TO Passes

   X$ = MID$(Need$, I, 1)

   SELECT CASE X$

       CASE "C"
       Cohesion = GetData("Cohesion (kPa) = ", "###.#", 6, 14)

       CASE "D"
       Density = GetData("Density (kN/cub m) = ", "##.##", 7, 10)

       CASE "F"
       Depth = GetData("Failure plane Depth (m) = ", "##.##", 8, 5)

       CASE "S"
       Slope = GetData("Slope angle (degrees) = ", "###.#", 9, 7)

       CASE "A"
       Friction = GetData("Angle of friction (degrees) = ", "###.#", 10, 1)

       CASE "P"
       PorePressure = GetData("Pore pressure ratio (Ru) = ", "##.##", 11, 4)

    END SELECT

NEXT I
```

```
END SUB

'============================== EraseMenu ================================
'Erases part of the screen display.
'=========================================================================
'
SUB EraseMenu

COLOR 7, 0

FOR J = 15 TO 23
      LOCATE J, 1: PRINT SPC(79);

NEXT J

END SUB

'============================== GetData ==================================
'Requests input (DataValue) for a model parameter by displaying the prompt
'Dataprompt$ at line (Row) column (Col).  The input value is formatted by
'UsePrompt$ and re-displayed.
'=========================================================================
'
FUNCTION GetData (Dataprompt$, UsePrompt$, Row, Col)

LOCATE Row, Col, 1, 0, 13: COLOR 7, 0: PRINT Dataprompt$;
Column = POS(0)
LOCATE Row, Column: PRINT SPACE$(10);
LOCATE Row, Column: INPUT "", DataValue
LOCATE Row, Column: PRINT USING UsePrompt$; DataValue

GetData = DataValue

END FUNCTION

'============================== GetFile ==================================
'Gets the specification of the file to which data will be saved.
'=========================================================================
'
FUNCTION GetFile$ (dmy$)

SCREEN 0, 0, 1, 1
CLS

Drive$ = GetString$("Provide disk drive", "A:", 12, 20)
IF LEN(Drive$) = 0 THEN
   Drive$ = "A:"
ELSEIF LEN(Drive$) = 1 AND Drive$ <> ":" THEN
   Drive$ = Drive$ + ":"
END IF

Path$ = GetString$("Path name", "\", 13, 29)
IF LEN(Path$) = 0 THEN
   Path$ = "\"
ELSEIF RIGHT$(Path$, 1) <> "\" THEN
   Path$ = Path$ + "\"
   IF LEFT$(Path$, 1) <> "\" THEN
       Path$ = "\" + Path$
   END IF
END IF

File$ = GetString$("File-name", "PLANAR", 14, 25)
IF LEN(File$) = 0 THEN
   File$ = "PLANAR"
ELSEIF LEN(File$) > 8 THEN
   File$ = LEFT$(File$, 8)
END IF

Extn$ = GetString$("Extension", "DAT", 15, 29)
IF LEN(Extn$) = 0 THEN
   Extn$ = "DAT"
ELSEIF LEN(Extn$) >3 THEN
```

```
   Extn$ = LEFT$(Extn$, 3)
END IF

FileSpec$ = Drive$ + Path$ + File$ + "." + Extn$

LOCATE 18, 1, 0: PRINT dmy$; : PRINT FileSpec$;

FOR J = 1 TO 2000: NEXT J

SCREEN 0, 0, 0, 0

GetFile$ = FileSpec$

END FUNCTION

'============================== GetString ==================================
'Displays a prompt (Prompt$) with a default value (Default$) at line (Row),
'column (Col) and requests an input (Name$).
'===========================================================================
'
FUNCTION GetString$ (Prompt$, Default$, Row, Col)

LOCATE Row, Col, 1, 0, 7: COLOR 7, 0: PRINT Prompt$
LOCATE Row, 40: PRINT Default$
LOCATE Row, 40: COLOR 15, 1: INPUT "", Name$

GetString$ = Name$

END FUNCTION

'============================== PrintData ==================================
'Prints the data and calculated Factor of Safety to the line printer.
'===========================================================================
'
SUB PrintData

SHARED CohesionYesNo, Slope, Friction, PorePressure, Cohesion, Depth, Density
SHARED FactorOfSafety, SiteId$, Printheader

LOCATE 21, 1: PRINT SPC(79);
LOCATE 21, 18: COLOR 7, 0: PRINT "PRINTING DATA"
Printheader = Printheader + 1

IF Printheader = 1 THEN
   LPRINT : LPRINT : LPRINT SiteId$
   LPRINT "    Slope   Friction    Pore                          Failure
Factor"
   LPRINT "    Angle      Angle   Press   Cohesion    Density     Plane
of"
   LPRINT "(degrees)   (degrees)   Ratio      (kPa) (kN/cub m)       (m)
Safety"
END IF

LPRINT USING "#######.#"; Slope;
LPRINT USING "#########.#"; Friction;
LPRINT USING "#####.##"; PorePressure;

IF CohesionYesNo = 2 THEN
   LPRINT "                                  ";
ELSE
   LPRINT USING "#########.#"; Cohesion;
   LPRINT USING "#########.#"; Density;
   LPRINT USING "########.#"; Depth;
END IF

LPRINT USING "######.##"; FactorOfSafety
LOCATE 21, 1: COLOR 7, 0: PRINT SPC(79);

END SUB
```

```
'================================ RangeData ==================================
'Automatically calculate the Factor of Safety for a range of an input
'parameter starting with StartValue and ending with EndValue in steps
'of StepValue.  The current value of the parameter is displayed as is the
'Factor of Safety.  Data is automatically sent to the line printer and
'saved to disk.
'=============================================================================
'
SUB RangeData

SHARED Change$, FactorOfSafety, Slope, Friction, PorePressure, Cohesion
SHARED Density, Depth, ChangeWhat, Filename$, CohesionYesNo, Printheader
SHARED DiskHeader, LineNum, RangeValue

LOCATE 19, 1, 1, 0, 7: COLOR 7, 0: PRINT SPC(79);

IF ChangeWhat = 1 THEN
   RangePrompt$ = "slope  : "
ELSEIF ChangeWhat = 2 THEN
   RangePrompt$ = "angle of friction : "
ELSEIF ChangeWhat = 3 THEN
   RangePrompt$ = "pore press ratio  : "
ELSEIF ChangeWhat = 4 THEN
   RangePrompt$ = "cohesion  : "
ELSEIF ChangeWhat = 5 THEN
   RangePrompt$ = "density  : "
ELSE
   RangePrompt$ = "failure plane depth  : "
END IF

LOCATE 19, 10: PRINT "Start value of "; RangePrompt$; : INPUT "", StartValue
LOCATE 20, 10: PRINT "  End value of "; RangePrompt$; : INPUT "", EndValue
LOCATE 21, 10: PRINT "Calculate in steps of  : "; : INPUT "", StepValue

FOR RangeValue = StartValue TO EndValue STEP StepValue

    SELECT CASE Change$

       CASE "S"
       Slope = RangeValue
       LineNum = 9

       CASE "A"
       Friction = RangeValue
       LineNum = 10

       CASE "P"
       PorePressure = RangeValue
       LineNum = 11

       CASE "C"
       Cohesion = RangeValue
       LineNum = 6

       CASE "D"
       Density = RangeValue
       LineNum = 7

       CASE "F"
       Depth = RangeValue
       LineNum = 8

   END SELECT

   EraseMenu

   LOCATE 19, 10: COLOR 15, 1
   PRINT "Auto-range calculations in progress for "; RangePrompt$

   ShowRange

   FactorOfSafety = CalculateResults
```

```
   ShowResults

   PrintData

   SaveData

NEXT RangeValue

END SUB

'================================ SaveData ==================================
'Saves the data and the calculated Factor of Safety to disk.
'============================================================================
'
SUB SaveData

SHARED CohesionYesNo, Slope, Friction, PorePressure, Cohesion, Depth, Density
SHARED FactorOfSafety, SiteId$, DiskHeader, Filename$

LOCATE 21, 1: PRINT SPC(79);
LOCATE 21, 18: COLOR 7, 0: PRINT "SAVING DATA"
DiskHeader = DiskHeader + 1

IF DiskHeader = 1 THEN
   Filename$ = GetFile$("File specification is...")
END IF

OPEN Filename$ FOR APPEND AS #1

IF DiskHeader = 1 THEN
   PRINT #1, SiteId$
   PRINT #1, "   Slope Friction     Pore                        Failure   Factor"
   PRINT #1, "   Angle    Angle    Press Cohesion  Density     Plane       of"
   PRINT #1, "   (deg)    (deg)    Ratio    (kPa) (kN/c m)       (m)   Safety"
END IF

PRINT #1, USING "######.#,"; Slope; Friction;
PRINT #1, USING "#####.##,"; PorePressure;

IF CohesionYesNo = 2 THEN
   PRINT #1, "       0,       0,       0,";
ELSE
   PRINT #1, USING "######.#,"; Cohesion; Density; Depth;
END IF

PRINT #1, USING "#####.##"; FactorOfSafety

CLOSE #1

LOCATE 21, 1: COLOR 7, 0: PRINT SPC(79);

END SUB

'================================ SetScene ==================================
'Clears the screen and requests site identification (SiteId$)and whether
'cohesion is to be used (CohesionYesNo) for calculations.  The data then
'required for input is passed on through Need$.
'============================================================================
'
SUB SetScene

SHARED Need$, CohesionYesNo, SiteId$

SCREEN 0, 0, 1, 1: CLS
SCREEN 0, 0, 0, 0: CLS

LOCATE 1, 20: COLOR 15, 1: PRINT "STABILITY ANALYSIS:   PLANAR FAILURE"
LOCATE 3, 1, 1, 0, 7: COLOR 7, 0: INPUT "Site Identification :  ", SiteId$

CohesionYesNo = AlphaKey(5, 1, 7, 0, "with COHESION (Y/N) :  ", "YN")

IF CohesionYesNo = 1 THEN
   Need$ = "CDFSAP"
```

```
ELSE
   Need$ = "SAP"
END IF

END SUB

'============================== ShowDataMenu ================================
'Displays the various parameters used in the calculations and requests
'which action (DataMenuPrompt$) is to be taken via ChangeWhat.
'============================================================================
'
SUB ShowDataMenu (DataMenuPrompt$)

SHARED Change$, CohesionYesNo, ChangeWhat

LOCATE 15, 1: COLOR 15, 1: PRINT DataMenuPrompt$

IF CohesionYesNo = 1 THEN
   LOCATE 15, 30: COLOR 15, 1: PRINT "C"; : COLOR 7, 0: PRINT "ohesion"
   LOCATE 16, 30: COLOR 15, 1: PRINT "D"; : COLOR 7, 0: PRINT "ensity"
   LOCATE 17, 30: COLOR 15, 1: PRINT "F"; : COLOR 7, 0: PRINT "ailure plane"
   What$ = "Enter S A P C D or F   : ": Valid$ = "SAPCDF"
ELSE
   What$ = "Enter S A or P  : ": Valid$ = "SAP"
END IF

LOCATE 15, 10: COLOR 15, 1: PRINT "S"; : COLOR 7, 0: PRINT "lope angle"
LOCATE 16, 10: COLOR 15, 1: PRINT "A"; : COLOR 7, 0: PRINT "ngle of friction"
LOCATE 17, 10: COLOR 15, 1: PRINT "P"; : COLOR 7, 0: PRINT "ore press ratio"

ChangeWhat = AlphaKey(19, 10, 15, 1, What$, Valid$)
Change$ = MID$(Valid$, ChangeWhat, 1)

END SUB

'============================== Showmenu ================================
'Displays the main options menu and requests a keyboard response
'(WhichOption).  It then controls execution of that option.
'============================================================================
'
SUB ShowMenu

SHARED CohesionYesNo, BeginAgain, ExitNow, Change$

EraseMenu

LOCATE 15, 1: COLOR 15, 1: PRINT "OPTIONS:"
LOCATE 15, 10: COLOR 15, 1: PRINT "A"; : COLOR 7, 0: PRINT "lter data"
LOCATE 16, 10: COLOR 15, 1: PRINT "B"; : COLOR 7, 0: PRINT "egin again"
LOCATE 17, 10: COLOR 15, 1: PRINT "E"; : COLOR 7, 0: PRINT "xit program"
LOCATE 15, 30: COLOR 15, 1: PRINT "P"; : COLOR 7, 0: PRINT "rint data"
LOCATE 16, 30: COLOR 15, 1: PRINT "S"; : COLOR 7, 0: PRINT "ave data"
LOCATE 17, 30: COLOR 15, 1: PRINT "R"; : COLOR 7, 0: PRINT "ange of values"

WhichOption = AlphaKey(19, 10, 15, 1, "Enter A B E P S or R  : ", "ABEPSR")

SELECT CASE WhichOption

   CASE 1
   EraseMenu
   ShowDataMenu ("CHANGE:")
   DataRequired (Change$)

   CASE 2
   BeginAgain = -1

   CASE 3
   BeginAgain = -1
   ExitNow = -1

   CASE 4
   PrintData
```

```
   CASE 5
   SaveData

   CASE 6
   EraseMenu
   ShowDataMenu ("RANGE:")
   RangeData

END SELECT

END SUB

'============================== ShowRange ==================================
'Displays the current value (ParameterValue) of a parameter at line Row
'for which a range calculation is being made automatically.
'===========================================================================
'
SUB ShowRange
SHARED LineNum, RangeValue

LOCATE LineNum, 31: COLOR 7, 0: PRINT SPC(10);
LOCATE LineNum, 31: PRINT RangeValue

END SUB

'============================== ShowResults ================================
'Displays the calculated Factor of Safety (FactorOfSafety).
'===========================================================================
'
SUB ShowResults

SHARED FactorOfSafety

LOCATE 13, 1: COLOR 7, 0: PRINT SPC(79);
LOCATE 13, 12: COLOR 15, 1: PRINT "Factor of Safety =";
PRINT USING "##.##"; FactorOfSafety
COLOR 7, 0

END SUB
```