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USER'S GUIDE: INTERACTIVE COMPUTER GRAPHICS SLOPE STABILITY PAC--ETC(U)
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USER'S GUIDE: INTERACTIVE COMPUTER GRAPHICS SLOPE STABILITY PACKAGE WITH DRUM PLOT CAPABILITIES (DGSLOPE)

by

Robert L. Hall, Paul K. Senter

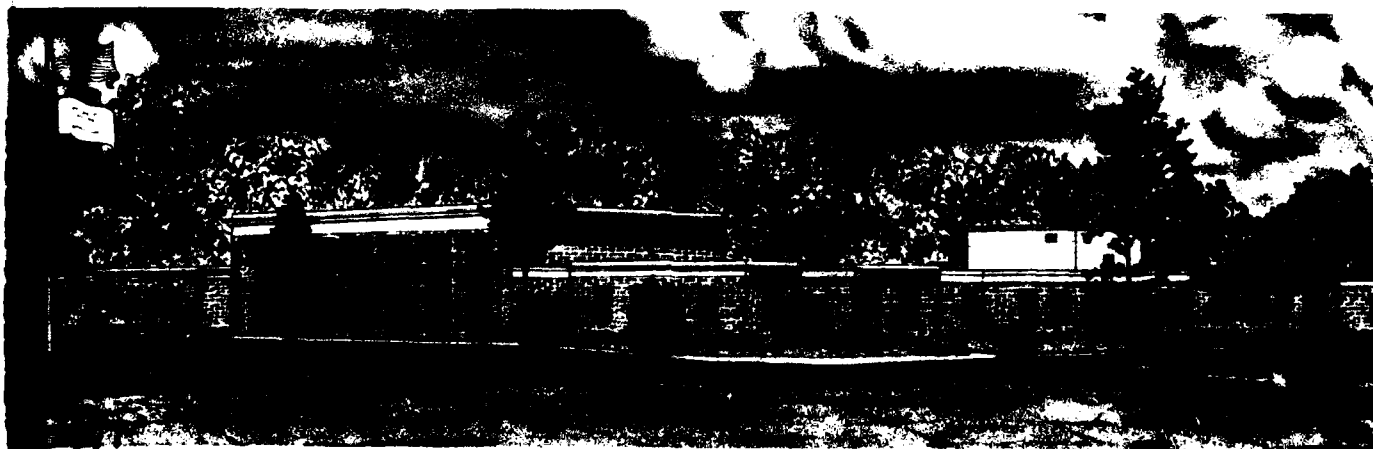
Automatic Data Processing Center
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

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Prepared for U. S. Army Engineer Division, Lower Mississippi Valley
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Preface

This report provides instructions for using DGSLOPE, an interactive computer graphics slope stability package with drum plot capabilities. An existing series of slope stability programs (SSA003, SSW028, and SSW39A) was combined to form the DGSLOPE package. This work was part of the operation of the joint U. S. Army Engineer Waterways Experiment Station (WES) and U. S. Army Engineer Division, Lower Mississippi Valley (LMVD), Computer Center for Fiscal Years 1978-1980. Partial funding for the work was also received from the Computation and Analysis Branch, Office, Chief of Engineers (OCE).

The series of slope stability programs was developed by Mr. James B. Cheek, formerly of the WES Automatic Data Processing (ADP) Center. The analytical procedures have been reported by Mr. Cheek in WES Miscellaneous Papers K-73-2, K-76-3, and K-77-1.

The program modifications documented herein were coded for the WES G-635 computer by Mr. Robert L. Hall, Mr. James M. Jones, and Ms. Janet Jackson, ADP Center. Mr. Mike Pace, ADP Center, and Ms. Jackson did considerable work in testing the program. This user's guide was prepared by Mr. Hall and Mr. Paul K. Senter, ADP Center, using major parts of the command descriptions as reported earlier by Mr. Cheek.

Work on the package was coordinated with the U. S. Army Engineer District, Vicksburg. Liaison was maintained between the District and WES by means of telephone conversations and office visits with Messrs. Larry A. Cooley and Eugene G. Wardlaw, Foundations and Materials Branch. Mr. Tony Young, Geology, Soils, and Materials Branch, was the LMVD point of contact. Mr. Rich Malm was the OCE point of contact. Dr. N. Radhakrishnan, Special Technical Assistant, ADP Center, was technical coordinator of the work, and Mr. Donald L. Neumann was Chief of the ADP Center.

COL J. L. Cannon, CE, and COL N. P. Conover, CE, were Directors of WES during the development of the program modifications. Mr. F. R. Brown was Technical Director.

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Conversion Factors, Inch-Pound to Metric (SI)
Units of Measurement

Inch-pound units of measurement used in this report can be converted to metric (SI) units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
feet	0.3048	metres
inches	2.54	centimetres
pounds (force) per square foot	47.88026	pascals
pounds (mass)	0.45359237	kilograms
pounds (mass) per cubic foot	16.01846	kilograms per cubic metre

USER'S GUIDE: INTERACTIVE COMPUTER GRAPHICS
SLOPE STABILITY PACKAGE WITH DRUM PLOT
CAPABILITIES (DGSLOPE)

Introduction

1. This report is a user's guide for DGSLOPE, a package of slope stability analysis programs with interactive graphics and drum plot capabilities. Three existing slope stability programs in the U. S. Army Engineer Waterways Experiment Station (WES) computer program library, WESLIB, were combined to form the DGSLOPE package. The first of these programs (SSA003*) utilizes the circular arc method of analysis; the other two (SSW028** and SSW39A+) employ two different wedge methods of analysis.

Input Features

2. DGSLOPE is easy to use because it allows the user to interact with the program in a conversational manner. It does not force the user to follow a sometimes inefficient data preparation procedure; rather, it allows him to dictate the program action using a series of simple commands.

3. The program assists the user in preparing input data in two ways. The first is by displaying the input graphically as it is being

* Cheek, J. B. 1973. "Instruction Manual for Using WES Time-Sharing System for Analysis of Slope Stability (The Circular Arc Method)," Miscellaneous Paper K-73-2, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

** _____. 1976. "Instruction Manual for Using Time-Sharing System for Analysis of Slope Stability; Wedge Method," Miscellaneous Paper K-76-3, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

+ _____. 1977. "Analysis of Slope Stability, Wedge Method Using Head Profiles to Model Uplift Pressures," Miscellaneous Paper K-77-1, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

defined. This allows visual monitoring of what information has been input. The second way is by prompting the user with data preparation instructions printed at the terminal following each command. Furthermore, to speed the input process on the time-sharing system, data can also be input from a previously prepared data file.

4. DGSLOPE checks the input data and prints error messages if the data violate program requirements. However, this feature does not guarantee the accuracy of the data. Therefore, the program has commands which allow the user to change much of the input.

Output

5. DGSLOPE provides plots from both the graphics storage tube terminal and a drum plotter. After completion of each stability analysis, the user can obtain a plot at his terminal of the soil profile, water profile, and failure surface. Upon completion of all analyses, the user can obtain a drum plot displaying the soil profile and failure surface for any or all of the individual analyses.

Overview of Operating Procedure

6. Although each facet of the operating procedure will subsequently be covered in detail, the following overview of the procedure describes how the facets interact.

7. Seated at the Tektronix 4014 terminal or its equivalent, the user calls the computer, identifies himself, and requests a run of DGSLOPE. The program asks for the name of a restart file (this file will be used to save the data used as input for the last stability calculations). The program then requests a data title, which the user supplies (this title will be stored in the first line of the restart file for identification purposes). The program then asks for a command, which the user supplies. Through this and subsequent commands, the program does any or all of the following: receives or alters soil properties, soil profiles, pool elevation, and neutral block base points; modifies the

computational procedure; and evaluates stability for the data stored. DGSLOPE also displays soil profiles, pool elevation, piezometric head points, neutral blocks, arcs, and the phreatic profile. After investigating several failure surfaces, the user may find it necessary to sign off and attend to other duties, even though he has not completed his analysis. He may do so without fear of losing his data because all the data items used in the last analysis are stored by the program in the restart file. They are ready for use when he next has an opportunity to work on the problem.

Input Preparation

Time-sharing mode

8. The following sequence of commands will start DGSLOPE time-sharing execution (user responses are underlined):

SYSTEM: FORT N

READY

*RUN MESLIB/DGSLOPE,R

9. The program now has control of the terminal and after a pause (whose length depends on the number and type of other time-sharing problems) will type:

GRAPHICAL SLOPE STABILITY ANALYSIS
WITH DRUM PLOTS

SUPPLY NAME OF RESTART FILE

=

The user then types in the desired file name and a carriage return. The program stores the file name and erases all data in that file. The user must therefore either give a new (previously unused) file name or be sure that the data stored under any old file name that he may reuse are no longer needed.

10. After this file is established, the program types:

SUPPLY TITLE FOR THIS RUN

=

The user supplies a title for this run that may contain up to 60 characters (blanks count as characters). This title will be written on the first line of the restart file. (Note that all data files must have a title on the first line.) By choosing data and restart file names in a systematic manner, such as making the first character a number, the user will be able to easily locate all data files and identify them by their title. This capability is most useful when many jobs and their associated files are being processed. Consequently, be sure to give accurate, meaningful titles to your runs.

11. After the title is saved, the program types:

ENTER COMMAND (LEVEL 1)

=

The user may now begin to use commands to enter, display, and/or run stability analyses. "Level 1" indicates that the program is expecting input commands for entering data. The "Level 2" commands are for control of getting drum plots of the output. If the user enters an invalid command, the program will print a list of valid commands, as shown below, and set for full conversational mode of interaction:

ENTER COMMAND (LEVEL 1)

=XXX

ARC DATA

SOIL DATA

PROGRAM CONTROL

NEUTRAL BLOCK

EDIT XXXX

POOL ELEVATIONS

PHREATIC PROFILE

PIEZOMETRIC HEAD

INSERT SOIL

GENERATE ARCS

RUN

CONVERSATIONAL OUTPUT

NO CONVERSATION OUTPUT

TABLE OF SOIL PROPERTIES

READ OLD DATA FILE

WINDOW PROFILE
DISPLAY PROFILE

ENTER COMMAND (LEVEL 1)

=

12. At this point, most users will be able to close this user's guide and follow the instructions given by the program at the terminal. However, the rest of this user's guide describes what can be expected from each command and the restrictions and limitations on the program and data.

Optional output

13. Detailed data preparation instructions can be called up with each data input command code. The output of the full conversational mode for each command is shown in the following text in capital letters. The optional output giving the detailed instructions is underlined.

Commands

Soil Input Command = SO

14. The program responds to command SO with:

SOIL 1 PROPERTIES

<u>SATURATED</u>	<u>Q TEST</u>	<u>R TEST</u>	<u>S TEST</u>
<u>UNIT WT.,</u>	<u>PHI, COHESION,</u>	<u>PHI, COHESION,</u>	<u>PHI, COHESION</u>

=

The user should then type in the saturated unit weight, in pounds per cubic foot, and the Q, R, and S test values for the friction angle (PHI), in degrees, and cohesion (C), in pounds per square foot. He should then strike a carriage return.

15. The program stores the properties and requests:

SOIL PROFILE

X(1), Y(1), X(2), Y(2), ... X(N), Y(N)

=

The user supplies these points (distance and elevation, in feet) on the exterior profile in ascending order by distance (X). Note that this exterior profile must extend beyond the surface intersection points of any wedges to be studied.

16. Should more than one line of data be required for the profile, the last point on the line should be followed by a comma and then a carriage return. The program will store this portion of the profile. When the program is ready for the remainder of the data, it will type an equal sign on the next line. Be sure to wait for the equal sign before supplying additional points.

17. The SO command is used repetitively to input the properties and profile data for the interior soils. The program numbers each new soil in steps of one starting with 1 for the first soil. Soils must be defined working from high elevations to low, because each profile erases all portions of profiles below it. Any valid portion of a profile erased by this procedure must be redefined with an additional lower soil.

18. The screen is erased and all data are displayed after each soil profile is defined. Figures 1-4 show examples of input and display for two soil layers. The soil profiles are displayed using the same scale factor in both the X and Y directions. The scale factor is chosen to use as much of the screen as possible. If a soil profile point is improperly input, the X and Y coordinates of the point can be changed using the EDIT SOIL (ED SO) command. The soil properties can be changed using the EDIT PROPERTIES (ED PR) command.

Neutral Block Command = NE

19. The NE command is used to input the coordinates of the end

```
ENTER COMMAND (LEVEL 1)
-SO
SOIL 1 PROPERTIES
-125.,30.,0.,30.,0.,30.,0.
SOIL PROFILE
--300.,400.,-250.,400.,-10.,480.,110.,480.
```

Figure 1. Input for soil 1 properties using SO command

ENTER COMMAND (LEVEL 1)

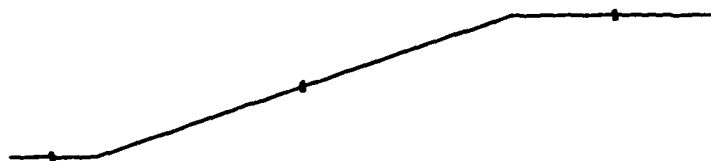


Figure 2. Display of soil 1 data using S0 command

ENTER COMMAND (LEVEL 1)

-S0

SOIL 2 PROPERTIES

-150.,45.,5000.,45.,5000.,45.,5000.

SOIL PROFILE

--300.,400.,-250.,400.,110.,400.

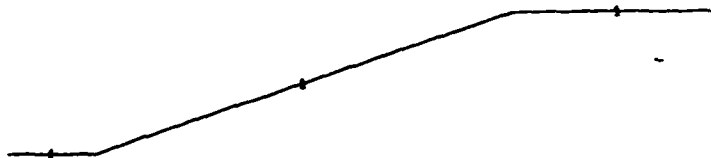


Figure 3. Input for soil 2 properties using S0 command

ENTER COMMAND (LEVEL 1)

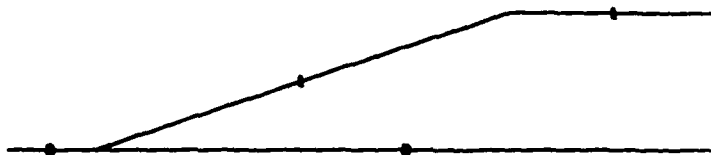


Figure 4. Display of soil 1 and 2 data using S0 command

points of the neutral block base used in the wedge method analysis. Also required is a computation control number which specifies the computations to be made according to the following code:

Computation Control No.	Program Action
1	Evaluates safety factors for after construction, sudden drawdown, partial pool, and critical pool. The embankment is saturated below the before drawdown pool elevation for the sudden drawdown case
0	Same as for number 1 except that the phreatic surface defined by command PH (paragraph 34) data is used in the drawdown computations. The elevation of the lower horizontal pool defined by the phreatic profile must be the same as the after drawdown pool elevation
-1	Evaluates safety factors for after construction, and steady seepage R and S strengths. The phreatic profile used for seepage computations is defined by the data input by the command PH. The lower elevation of the phreatic profile must be the same as the tailwater elevation
-2	Same as -1 except that the phreatic profile is horizontal at the headwater elevation out to the shell, coincident with the shell down to the tailwater elevation, and horizontal at the tailwater elevation

20. The program responds to the NE command with:

NEUTRAL BLOCK BASE n

LEFT	RIGHT	COMPUTATION
X, Y,	X, Y,	CONTROL
=		

where n is the neutral block number assigned by the program.

21. The user may use the NE command to establish a group of up to 25 neutral blocks for subsequent analysis. After each neutral block is defined, it is displayed with the soil profile as shown in Figures 5 and 6.

Arc Input Command = AR

22. The program responds to the AR command with:

```

ENTER COMMAND (LEVEL 1)
-NE

NEUTRAL BLOCK BASE NUMBER  1

LEFT  RIGHT  COMPUTATION
X,  Y,  X,  Y,  CONTROL
--150. 400. 0. 400. 1

```

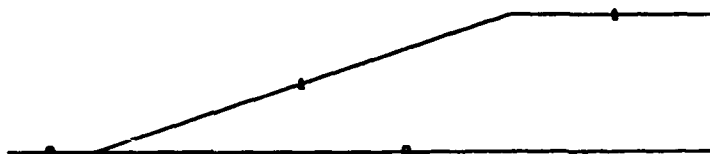


Figure 5. Input using NE command with soil profiles on screen

```

ENTER COMMAND (LEVEL 1)
-NE

NEUTRAL BLOCK BASE NUMBER  1

LEFT  RIGHT  COMPUTATION
X,  Y,  X,  Y,  CONTROL
--150. 400. 0. 400. 1

ENTER COMMAND (LEVEL 1)
.

```

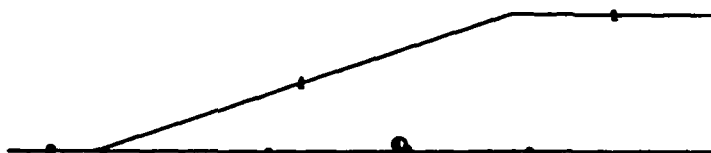


Figure 6. Display resulting from NE command

ARC 1

ARC CENTER AT	ARC	COMPUTATION
DISTANCE, ELEVATION,	RADIUS,	CONTROL FLAG
=		

The user supplies the distance and elevation of the arc center in feet, the arc radius in feet, and the program computation control flag. Successive items of data are separated by commas. The computation control flag selects the computation to be made for this arc, based on the following code:

Computation Control Flag	Program Action
1	Evaluates safety factors for after construction, sudden drawdown, partial pool, and critical pool. The embankment is saturated below the before drawdown pool elevation for the sudden drawdown case
0	Same as for number 1 except that the phreatic surface defined by phreatic profile data is used in the drawdown computations. The elevation of the lower horizontal pool defined by the phreatic profile must be the same as the after drawdown pool elevation
-1	Evaluates safety factors for after construction and steady seepage R and S strengths. The phreatic profile used for seepage computations is defined by command PH. The lower elevation of the phreatic profile must be the same as the tailwater elevation
-2	Same as -1 except that the phreatic profile is horizontal at the headwater elevation out to the shell, coincident with the shell down to the tailwater elevation, and horizontal at the tailwater elevation

23. By repeating the AR command, a group of up to 25 arcs may be stored for subsequent computation. Each arc is numbered from 1 through 25 by the program. The group of arcs is considered complete when the command RU AR (calculate arc stability) (paragraph 54) is given. The group may be used repeatedly while soil, phreatic profile, pool, and control data are modified. After each arc is input (Figure 7), it is displayed as seen in Figure 8. Arcs which do not intersect the embankment surface and those having intersections higher than the arc center (overhanging failure surface) will produce error notes.

Arc Generating Command = GE

24. The arc generating routine produces a family of arcs that are all tangent to a horizontal plane and pass through a common point. The program has two modes of operation, selected by the KASE value (paragraph 26). The operating modes and computations set by each KASE value are discussed in the following paragraphs.

25. Arc generating mode. The generating mode calculates slope stability for a series of arcs, starting with radius RS, and increasing the radius of successive arcs by DEL until radius RF is used. All arcs

ENTER COMMAND (LEVEL 1)

-AR
ARC 1

ARC CENTER AT DISTANCE, ELEVATION,	ARC RADIUS,	COMPUTATION CONTROL FLAG
--30. 500. 90. 1		

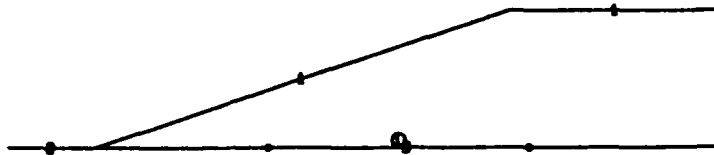


Figure 7. Input using AR command

ENTER COMMAND (LEVEL 1)

-AR
ARC 1

ARC CENTER AT DISTANCE, ELEVATION,	ARC RADIUS,	COMPUTATION CONTROL FLAG
--30. 500. 90. 1		

ENTER COMMAND (LEVEL 1)

.

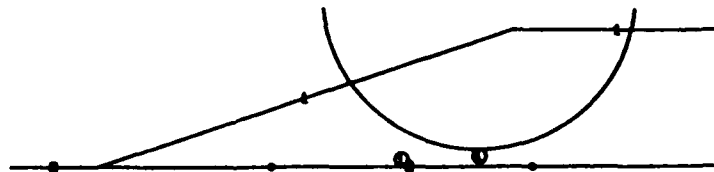


Figure 8. Display resulting from AR command

in the group are tangent to a plane at elevation EL and pass through the point XP, YP. (The above criteria were chosen to aid in investigating a circular failure surface that passes through a point on or within the embankment and is coincident with a relatively weak horizontal stratum). Program operation is unchanged except that arcs are produced automatically and KASE takes on the function of the computation control flag.

26. Arc searching mode. The searching mode differs from the generating mode in the following respects:

- a. The program stops the arc generating process when the safety factor computed for the current arc is greater than

the safety factor computed for the previous arc of the group. The effect of this feature is to halt the generating process when a minimum safety factor has been found, based on the assumption that arcs having longer radii will produce larger safety factors.

- b. Only one stability analysis case is computed.
- c. The variable KASE is used to select the stability analysis case to be used. Only values 2 through 6 may be used for this searching mode.
- d. The previously established delete options are erased. (The delete options must be reset via command PR (paragraph 29) before the program is used in any other computation mode.)

Program action for each KASE value is as follows:

<u>KASE</u>	<u>Program Action</u>
-2	Computes after construction, steady seepage R strength, and steady seepage S strength cases. Assumes saturated-to-shell conditions below the headwater elevation for seepage computations
-1	Same as -2 except that the <u>tailwater elevation and phreatic profile data</u> are used in seepage computations
0	Computes after construction, sudden drawdown, and partial pool cases and locates the critical pool elevation. <u>The after drawdown pool elevation and phreatic profile data are used in the sudden drawdown computations</u>
1	Same as 0 except that saturated-to-shell conditions are assumed below the before drawdown pool elevation for the sudden drawdown computations
2	Computes only after construction case
3	Computes only sudden drawdown case
4	Computes only partial pool case
5	Computes only steady seepage R strength case
6	Computes only steady seepage S strength case

Note that the KASE numbers 2 through 6 have the reverse effect of the same delete options (paragraph 31); that is, they allow only the prescribed computation rather than delete one and allow all others.

27. The program responds to command GE with:

ARC GENERATING PARAMETERS

KASE, XP, YP, EL, RS, DEL, RF, DIR
=

The functions of the eight arc generating parameters are presented below:

Parameter Name	Used For
KASE	Computation control
XP, YP	The distance and elevation coordinates, respectively, of the common point
EL	The elevation of the horizontal plane
RS	The radius of the initial arc. The arc center must be above the highest point on the failure surface; that is, RS must be greater than (YP - EL)
DEL	The difference in the radius of successive arcs
RF	The maximum generated arc length
DIR	Indicates whether arc centers are on the left (DIR = -1) or right (DIR = 1) of the common point

28. Changes in program and data. The following major changes take place when the arc generator is used:

- a. All arc data previously stored are not used.
- b. Only the strength selector and print control delete options (numbers 1 and 8) will remain unchanged.

After the arc generated parameters have been input, the first arc is displayed as seen in Figures 9 and 10.

```

ENTER COMMAND (LEVEL 1)
-GE
ARC GENERATING PARAMETERS
KASE, XP, YP, EL, RS, DEL, RF, DIR
-5 -225 450. 410. 100. 5 120. 1

```

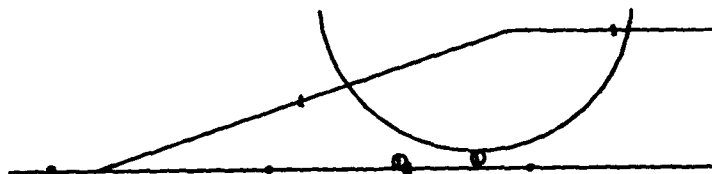


Figure 9. Input using GE command

Program Control Command = PR

29. This command is used only when one or more of the following

ENTER COMMAND (LEVEL 1)

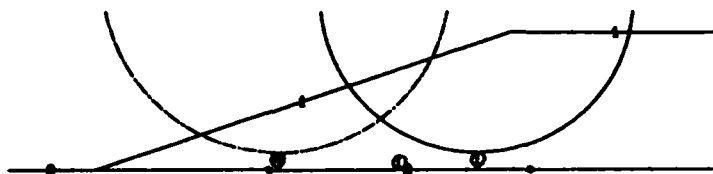


Figure 10. Display resulting from GE command

standard values or options are unacceptable (items a and b apply only to the arc program):

- a. Earthquake acceleration is 0.05 g's.
- b. Number of slices is 20.
- c. Computations for positive computation control flag are:
after construction, sudden drawdown, partial pool, and
critical pool.
- d. Computations for negative computation control flag are:
after construction, steady seepage R strengths, and
steady seepage S strengths.
- e. After construction analysis uses Q strengths at the fail-
ure surface of each slice, without regard to the
groundwater.
- f. Program output to include the tabulation of failure sur-
face coordinates, weight, and head of water at each seg-
ment of the failure surface.
- g. Program output to include a tabulation of the input data.

30. The program responds to command PR with:

PROGRAM CONTROL

EARTHQUAKE NUMBER LIST THE NUMBER OF EACH
G LOAD, OF SLICES, DELETE OPTION DESIRED
=

The user supplies the earthquake horizontal acceleration in units of

gravity, the number of slices (the maximum is 30, required for compatibility with the arc method program), and the number for each delete option required for subsequent computations. All previously established delete options are removed.

31. The program action for each delete option is shown below for all programs in this series:

Number	Program Action
1	Uses R instead of Q strength below the groundwater elevation for after construction case
2	Deletes computation of after construction case
3	Deletes computation of sudden drawdown case
4	Deletes computation of partial and critical pool cases
5	Deletes computation of steady seepage R strength case
6	Deletes computation of steady seepage S strength case
7	Deletes computation of critical pool location
8	Deletes failure surface coordinate printing
9	Deletes plotting of soil data and failure surface after each analysis

The PR command, as used for deleting the critical pool calculations, is illustrated in Figure 11.

ENTER COMMAND (LEVEL 1)
-PR
PROGRAM CONTROL

EARTHQUAKE NUMBER LIST THE NUMBER OF EACH
G LOAD, OF SLICES, DELETE OPTION DESIRED
- .05, 20, 7

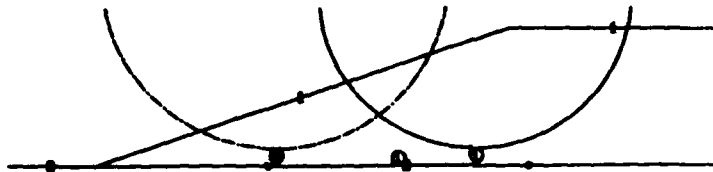


Figure 11. Input using PR command

Pool Input Command = PO

32. The program responds to this command with:

POOL EL.

GROUNDWATER FOR	PARTIAL	BEFORE	AFTER	SEEPAGE	SEEPAGE
CONSTRUCTION CASE,	POOL,	DRAWDOWN,	DRAWDOWN,	HEADWATER,	TAILWATER
=					

The user replies with elevations for the pools. Pool elevations must reference the same elevation datum as other coordinate data (soil profile, phreatic profile, and arc center). The program supplies an initial value of zero for the pool elevations. This zero value will be used in all computations if the pool command is not given.

33. The function of each pool elevation in the computation procedure is as follows:

- a. The groundwater elevation is used in the after construction computations. The program uses saturated unit weight with Q shear strength data above this elevation and submerged unit weight with Q shear strength data below this elevation. Delete option 1 causes R strength data to be used below this elevation and Q strength data above.
- b. The partial pool elevation is used during upstream analysis (wedge computation control value of 1 or 0). The safety factor is computed for the partial pool at this elevation using R shear strength data. The program uses saturated unit weight above the pool and submerged unit weight below. This feature allows the user to study pool elevations that are independent of those chosen by the automatic critical pool location procedure.
- c. The before drawdown elevation is used during upstream analysis as the upper elevation for sudden drawdown saturated-to-shell computations (wedge computation control value of 1). This value is ignored when the sudden drawdown phreatic surface is defined by phreatic profile data.
- d. The after drawdown elevation specifies the elevation of the pool after sudden drawdown has taken place. This value is used during the upstream analysis of sudden drawdown computations (wedge computation control values of 0 and 1). This value must agree with the lowest elevation of the phreatic profile data when those data are used to define the sudden drawdown phreatic surface (wedge computation control value of 0).
- e. The headwater elevation is used during downstream analysis as the upper pool elevation for saturated-to-shell steady seepage computations (wedge computation control value of -1). This value is ignored when the seepage

phreatic surface is defined by phreatic profile data (wedge computation control value of -2).

- f. The tailwater elevation specifies the lower pool elevation used in downstream analysis of steady seepage (wedge computation control values of -1 and -2). This value must agree with the lowest elevation of the phreatic profile data when they are used to define the steady seepage phreatic surface profiles (wedge computation value of -1).

The pool elevations are displayed after all pools have been input, as shown in Figures 12 and 13.

ENTER COMMAND (LEVEL 1)
-PO

POOL EL.

GROUNDWATER FOR	PARTIAL BEFORE	AFTER	SEEPAGE	SEEPAGE
CONSTRUCTION CASE,	POOL,	DRAUDOWN,	DRAUDOWN,	HEADWATER, TAILWATER
-400.	430.	470.	450.	470. 450.

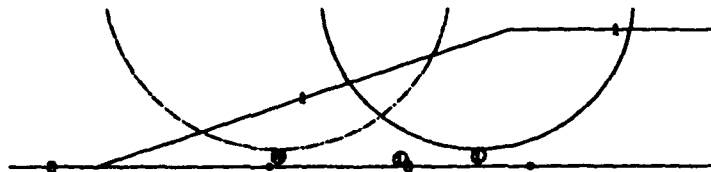


Figure 12. Input using PO command

ENTER COMMAND (LEVEL 1)
-PO

POOL EL.

GROUNDWATER FOR	PARTIAL BEFORE	AFTER	SEEPAGE	SEEPAGE
CONSTRUCTION CASE,	POOL,	DRAUDOWN,	DRAUDOWN,	HEADWATER, TAILWATER
-400.	430.	470.	450.	470. 450.

ENTER COMMAND (LEVEL 1)

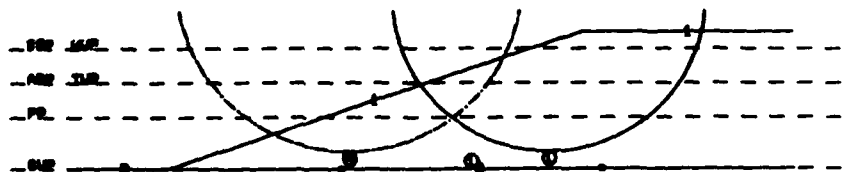


Figure 13. Display resulting from PO command

Phreatic Profile Input Command = PH

34. The program responds to this command with:

PHREATIC PROFILE POINTS

X(1), Y(1), X(2), Y(2), ... X(N), Y(N)

The user replies with the distance (X) and elevation (Y) coordinates, in feet, of the points that describe the profile of either the sudden drawdown or steady seepage phreatic surface.

35. The phreatic profile points must be in ascending numerical order by distance. It is unlikely that one profile can be used to define both seepage and drawdown conditions, although the program will attempt to use whatever phreatic profile data are stored in the analysis of either or both conditions. The best practice is to define either the seepage or drawdown profile phreatic surface and make all calculations required. Then define the other phreatic surface and complete the remaining calculations. Figures 14 and 15 show the display of the phreatic profile data.

```
ENTER COMMAND (LEVEL 1)
=PH
PHREATIC PROFILE POINTS
X(1), Y(1), X(2), Y(2), ... X(N), Y(N)
--75. 450. -50. 460. 0. 465. 50. 470.
```

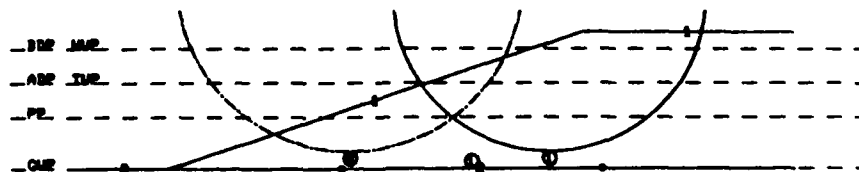


Figure 14. Input using PH command

Piezometric Head
Profile Command = PI

36. The program responds to this command with:

```

ENTER COMMAND (LEVEL 1)
PH
PHREATIC PROFILE POINTS
X(1), Y(1), X(2), Y(2), ... X(N), Y(N)
--75. 450. -50. 460. 0. 465. 50. 470.

```

```

ENTER COMMAND (LEVEL 1)

```

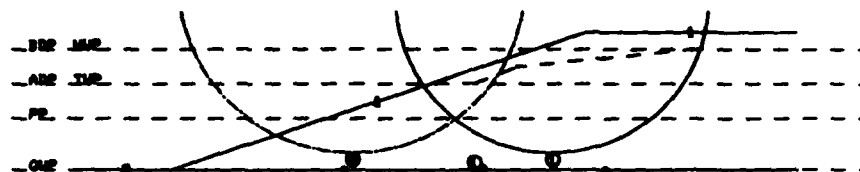


Figure 15. Display resulting from PH command

PIEZOMETRIC HEAD PROFILE

```

X(1), Y(1), H(1), X(2), Y(2), H(2), ... X(N), Y(N), H(N)
=

```

The user supplies the head data profile points consisting of the distance and elevation of each point and the piezometric head, in feet, at that point. As previously noted, the points on each head data profile must be recorded in ascending order of distance.

37. Should more than one line of data be required for the head of any profile, the last head value on the line should be followed by a comma and then a carriage return. The program will store this portion of the profile data. When it is ready for additional data, the program will type an equals sign on the next line. Be sure to wait for the equals sign before supplying additional data. Note that the first profile must define the phreatic surface. (Head values must be zero.) Each additional profile is supplied by giving command PI followed by the data for that profile. Figures 16 and 17 show the display of the piezometric head profile data.

Conversational Mode Command = CO

38. The conversational mode is an optional feature which does not become effective until an invalid command or the CO command is given. The CO command causes the program to provide additional input

```

ENTER COMMAND (LEVEL 1)
-PI
PIEZOMETRIC HEAD POINTS
X(1),Y(1),H(1),X(2),Y(2),H(2), ... X(N),Y(N),H(N)
--250 450 0 -100 450 0 -10 480 0 110 480 0

```

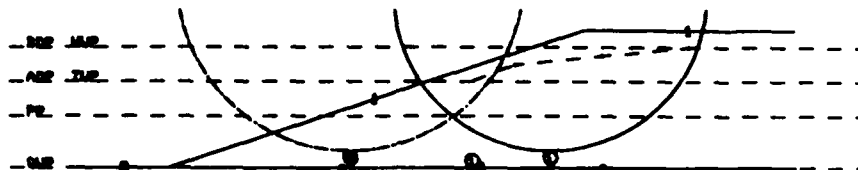


Figure 16. Input using PI command

```

ENTER COMMAND (LEVEL 1)
-PI
PIEZOMETRIC HEAD POINTS
X(1),Y(1),H(1),X(2),Y(2),H(2), ... X(N),Y(N),H(N)
--250 300 150 -100 300 150 -10 300 190 110 300 180

```

```

ENTER COMMAND (LEVEL 1)
.

```

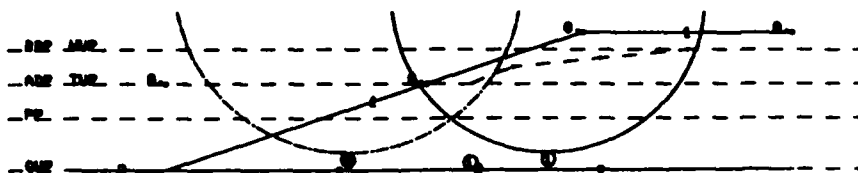


Figure 17. Display resulting from PI command

instructions for the data input command codes.

Delete Conversa-
tional Mode Command = NO

39. This command deletes the conversational text associated with its response to the command CO. As mentioned previously, the teletype output controlled by command CO is underlined in this report.

Read Data From An Old File = RE

40. This command causes the program to request the following:

SUPPLY THE NAME OF THE INPUT DATA FILE

=

The user must supply the name (4 to 8 characters) of the file that contains the input data and then a carriage return. After the file name is stored, the program will then change from the conversational mode to the unattended mode of operation. It will read the successive lines of data in the input file.

41. When all the data have been used, the program will return to the restricted conversational (experienced user) mode and request the next command from the terminal. At this point, the user may change or process the data presently in storage or read and process data from another file. A simple example using this mode of input is shown in Figures 18 and 19.

```
ENTER COMMAND (LEVEL 1)
-READ
SUPPLY NAME OF INPUT DATA FILE
-RE
```

Figure 18. Input using
RE command

ENTER COMMAND (LEVEL 1)

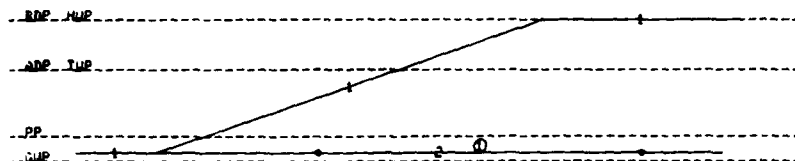


Figure 19. Display resulting from RE command

Insert New Soil Command = IN

42. This command performs the following functions:

- a. Erases all data for soils whose numbers are between N and M.

- b. Sets the program to receive a new soil (properties and profile).
- c. Inserts the new soil between numbers N and M.
- d. Renumbers the soils (starting with 1 for the first soil and continuing in steps of 1 for all soils).
- e. Sets the program to add additional soils to the end of the soil list through the SO command.

43. The program responds to the command IN with:

SOIL INSERTION NUMBERS

SOIL TO FOLLOW WILL BE PLACED BETWEEN SOIL N AND
SOIL M. N MUST BE LESS THAN M. SOILS (N+1)
THROUGH (M-1) ARE ERASED. SUPPLY VALUES FOR N AND M
 =

The user supplies values for the soil numbers N and M. The new soil will be placed between soil N and soil M. If M is greater than N+1, soils N+1 through M-1 will be erased and the new soil inserted. If M is greater than the last soil number, then all of the soils from N+1 through the end of the soil list will be erased. If M is less than N, an error note will be printed. Soil N must be present or an error note will be printed.

44. The program replies with:

SOIL (N+1) PROPERTIES

=

SOIL PROFILE

=

where (N+1) is the number assigned to the soil being inserted. Supply the necessary information as described in SO command, paragraphs 14-18. After an IN command, a SO command may be used to add soils to the end of the existing soil list. For example, if there are 6 soils present and the user desires to delete soils 4 and 5 and change soil 3, he would use values of 2 and 6, respectively, for N and M. After recording the new profile and properties for soil 3, the program would renumber all soils, and in so doing it would change the number of soil 6 to 4. If the user gives an SO command, the program would store that soil data after

soil 4. It would assign the number 5 to that new soil.

Table of Soil

Properties Command = TA

45. This command provides the user with a current listing of the unit weight and the angle of internal friction and angle of cohesion for the Q, R, and S strength test for each soil. If improper data have been entered, the user may change the material properties with a ED MA command. The use of the TA command is shown in Figure 20.

ENTER COMMAND (LEVEL 1)

*TA

SOIL	GAM	- S	PHI	- C	PHI	- C	PHI	- C
1	125.00	30.	0.	30.	0.	30.		
2	120.00	10.	3000.00	10.	3000.00	10.		

ENTER COMMAND (LEVEL 1)

*

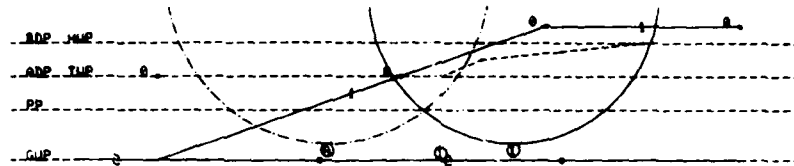


Figure 20. Table of soil properties listed using TA command

Change Material

Properties Command = ED PR

46. The program responds to this command with:

SOIL NUMBER TO BE CHANGED

=

The user replies with the number of any soil previously defined. An error message will be typed if a soil having this number is not present. After locating this soil, the program types:

SOIL i PROPERTIES

SATURATED	Q TEST	R TEST	S TEST
UNIT WT., PHI, COHESION,	PHI, COHESION,	PHI, COHESION,	PHI, COHESION

=

where i is the number of the soil requested. The user responds to this

request with the new soil properties as described in the section on command SO. All values requested must be input, even though they are the same as the previously stored data.

Edit Soil Profile Command = ED SO

47. The program responds to this command by first displaying the cross hairs. The user must then move the cross hairs to the soil profile point and enter a character and a carriage return. The program will then respond with the following:

PRESENT X AND Y COORDINATE ARE

13.00 14.00

ENTER NEW COORDINATES

=

The program will then change all soil profiles which contain the X-Y coordinates picked by the cross hairs to the new coordinates input. The screen will be erased and the new data displayed as shown in Figures 21 and 22.

ENTER COMMAND (LEVEL 1)
-ED SO

PRESENT X AND Y COORDINATES ARE:

-10.00 480.00
INPUT NEW COORDINATES
--10. 450.

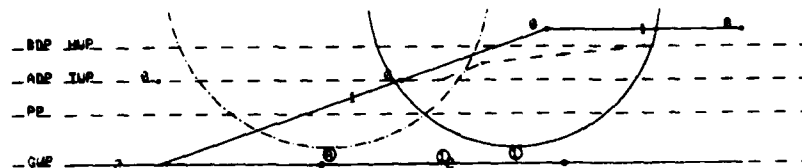


Figure 21. Input using ED SO command

Edit Phreatic Profile Command = ED PH

48. The program responds to the command ED PH by displaying the cross hairs. The user must then move the cross hairs to the desired phreatic profile point and enter a character and a carriage return.

ENTER COMMAND (LEVEL 1)

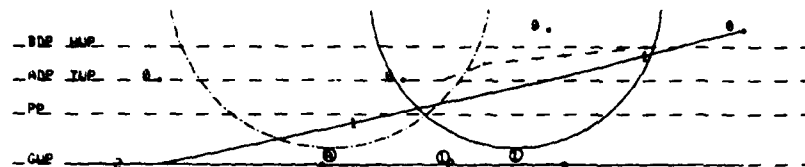


Figure 22. Display resulting from ED S0 command

The program will then respond with the following:

PRESENT X AND Y COORDINATES ARE

13.00 14.00

ENTER NEW COORDINATES

=

The screen will then be erased and the new data will be displayed as shown in Figures 23 and 24.

ENTER COMMAND (LEVEL 1)

•ED PH

PRESENT X AND Y COORDINATES ARE:

-120.00 450.00

INPUT NEW COORDINATES

--90.,450

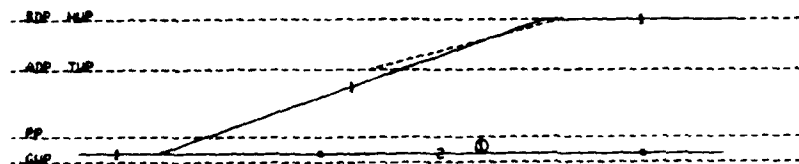


Figure 23. Editing of phreatic profile

ENTER COMMAND (LEVEL 1)

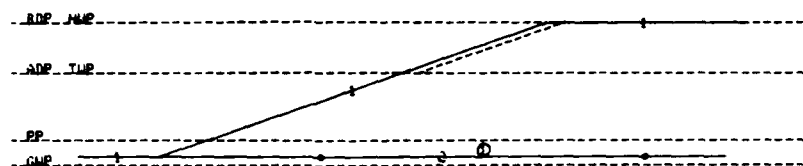


Figure 24. Display of edited phreatic profile

Window Command = WI

49. This command allows the user to pick any rectangular area of the display and magnify it to fill the entire screen. This provides the user with all the necessary detail required in checking the input data. The program responds to this command by displaying the cross hairs. The cross hairs should then be moved to the bottom left-hand corner of the area to be magnified. A character must be then entered followed by a carriage return. The cross hairs will reappear and should be moved to the upper right-hand corner of the desired area. Another character and a carriage return should be entered. The user can continue giving the WI command to "window" areas of the previous window. To redisplay the entire problem again, the command DI should be entered. Use of the WI command is shown in Figures 25 and 26.

Display All Data Command = DI

50. The program will respond to this command by erasing the screen and displaying all defined data as shown in Figure 27 and 28. The display data will use as much of the screen as possible using the same X and Y scale factors.

ENTER COMMAND (LEVEL 1)
=UI

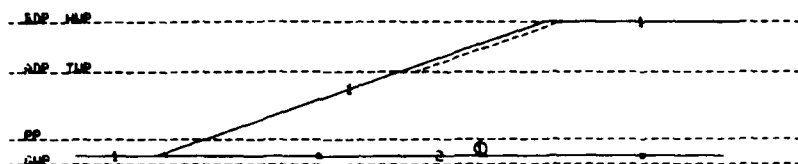


Figure 25. Input using WI command

ENTER COMMAND (LEVEL 1)
=

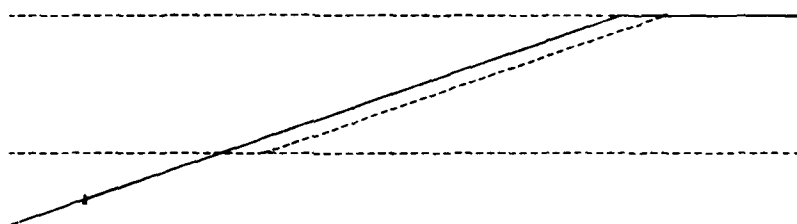


Figure 26. Display resulting from WI command

ENTER COMMAND (LEVEL 1)
=DI

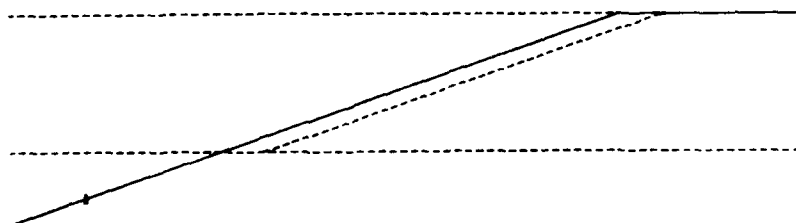


Figure 27. Input using DI command

ENTER COMMAND (LEVEL 1)
-RUN WE

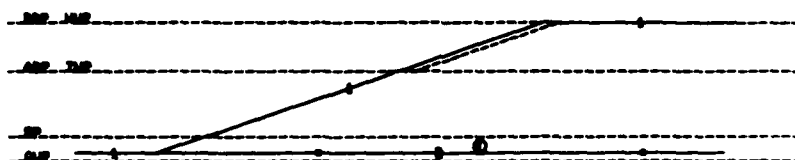


Figure 28. Display resulting from DI command and input of RU WE command

Execution of Data

Execute Wedge

Analysis Command = RU WE

51. This command causes the program to calculate the slope stability using the wedge method for the problem represented by the current display. It also saves all data input in the restart data file. Figures 29 and 30 demonstrate use of the RU WE command.

```

NEUTRAL BLOCK BASE 1
-150.00, 400.00 50.00, 400.00

AFTER CONSTRUCTION CASE USED 0 STRGTH BELOW GR WATER 395.000

INITIAL FACTOR OF SAFETY = 3.30
CROSS-OVER OCCURS AT STA. -70.46

  X      Y  WEIGHT  UPLIFT  SOIL
-170.00 404.00  22304.  0.  1
-150.00 400.00  45300.  0.  1
-70.46  400.00  520440.  0.  2
-10.00  400.00  800000.  0.  2
  50.00  400.00  317747.  0.  1
 100.00 450.32  10000.  0.  1
 110.00 400.00    0.  0.  1
 110.01 470.00    0.  0.  0

  L WEDGE  N BLOCK  R WEDGE  TOTAL
FB  94002.00      0. -303720.35 -343720.37
FR 100027.00 201005.74 104320.12 343052.64
S.F. = 3.730

```

Figure 29. Wedge analysis of slope

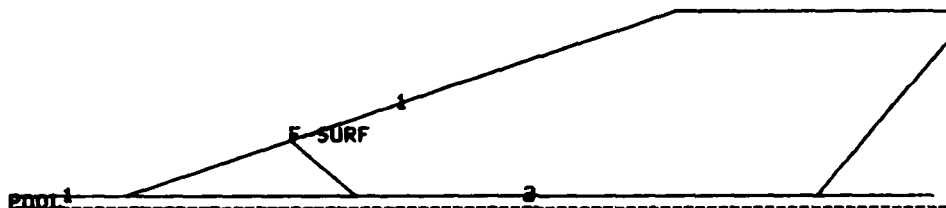


Figure 30. Display of failure surface from wedge analysis

52. Figure 29 shows the output for the stability analysis for neutral block 1. This output includes the following:

- a. The coordinates, in feet, of the end points of the neutral block base.
- b. The coordinates, in feet, of the end points that define the line segments that make up the failure surface.
- c. The weight, in pounds, of the soil above each failure surface segment.
- d. The head of water, in feet, that is effective at each end point.
- e. The number of the soil through which each failure segment passes.
- f. A tabulation of the horizontal components of the driving and resisting forces for the left wedge, neutral block, right wedge, and the total. Note that this tabulation is for the forces that were calculated for the last trial using the developed friction angle.
- g. The safety factor for this problem printed as the last line in the output. Note that a negative sign on the safety factor indicates that the direction of failure is from right to left.

Execute Wedge Analysis With
Piezometric Head Command = RU PI

53. This command causes the program to calculate the slope stability using a wedge method with piezometric heads for the problem represented by the current display. The data are also saved in the restart data file. Figures 31-33 demonstrate use of the RU PI command.

Execute Arc
Analysis Command = RU AR

54. This command causes the program to calculate the slope

```

NEUTRAL BLOCK BASE      1
-150.00,    400.00      0. ,    400.00

      X      Y      WEIGHT      HEAD      SOIL
-151.00  400.00  100104.  87.00  1
-150.00  400.00  888487.  80.00  1
-100.01  400.00      31.  87.00  1
-100.00  400.00  731170.  87.00  1
-10.01   400.00  100000.  80.00  1
0.       400.00  200004.  72.11  1
57.71   400.00      0.    0.    0

      L WEDGE      N BLOCK      R WEDGE      TOTAL
FD    101873.85      0.      -400000.01  -298126.15
FR    21884.20    171061.19    105375.98   298321.37

S.F. = 1.738

```

Figure 31. Input for wedge analysis using RU PI command

```

ENTER COMMAND (LEVEL 1)
-RUN PI

```

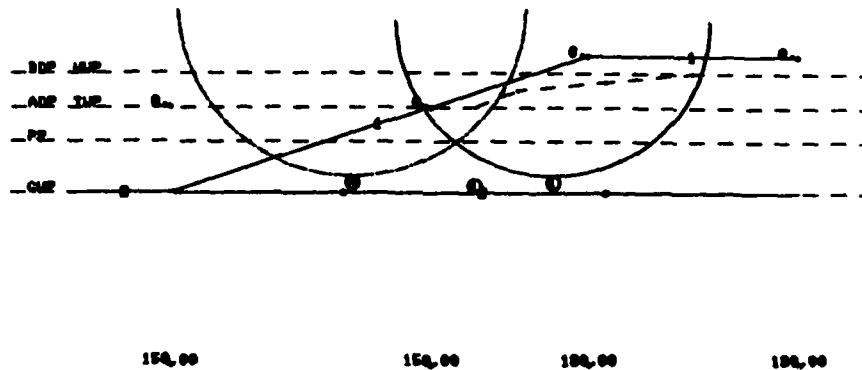


Figure 32. Display resulting from wedge analysis using RU PI command

stability using the arc analysis method for the problem represented by the current display. The data are also saved in the restart data file. Figures 34-36 demonstrate use of the RU AR command.

Input Data File Format

55. The format of the data in the input file is, in all respects but one, identical with that supplied by a user who is working with this program in the conversational mode. The exception is that line numbers are required for each line of data. The example in Figure 37

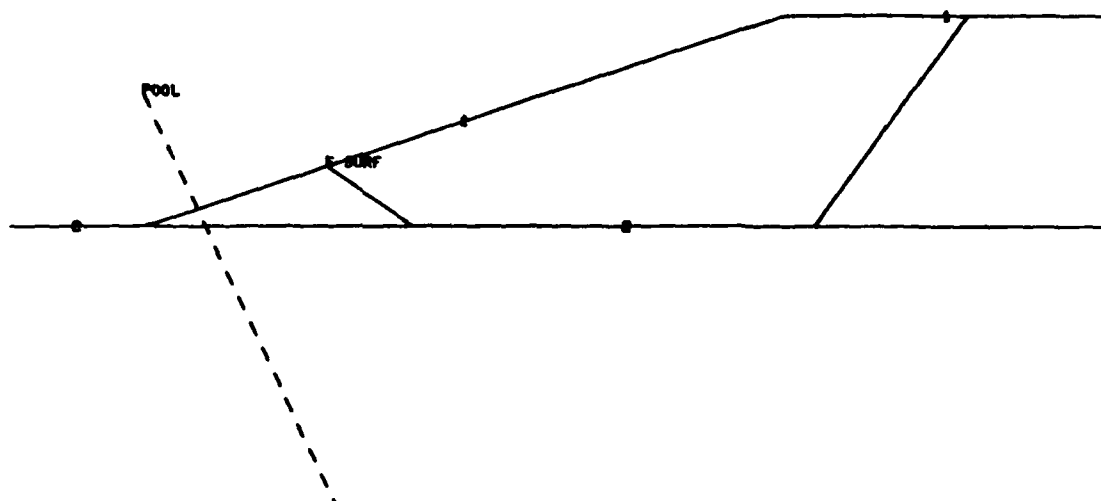


Figure 33. Display of failure surface from wedge analysis using
RU PI command

ENTER COMMAND (LEVEL 1)
-RUN AR

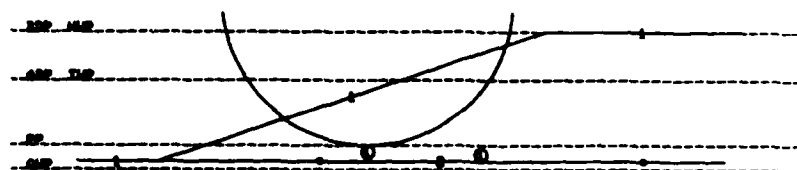


Figure 34. Input for arc analysis using RU AR command

SLOPE STABILITY , ARC METHOD
BY J CHEEK , MES , JULY 72

A DRUMPLOT CAN BE MADE OF LAST 25 ANALYSES.

ARC 1 OF 1
X = -120.00 Y = 500.00 R = 90.00

SLICE	X	Y	H	SOIL
1	-171.4763	425.1746	0.	1
2	-164.3029	421.7104	6.8253	1
3	-156.8254	417.8237	13.1012	1
4	-149.1382	414.8474	18.7732	1
5	-141.0000	412.5001	23.7023	1
6	-132.8770	410.3020	28.1150	1
7	-124.5436	410.1148	31.7040	1
8	-116.1700	410.0015	34.5282	1
9	-107.8314	410.8264	36.5631	1
10	-99.5872	412.3421	37.7911	1
11	-91.5395	414.6185	38.2017	1
12	-83.7282	417.6388	37.7911	1
13	-76.2307	421.3600	36.5631	1
14	-69.1121	425.7678	34.5282	1
15	-62.4330	430.8100	31.7040	1
16	-56.2540	436.4670	28.1150	1
17	-50.6257	442.6659	23.7023	1
18	-45.5979	449.3600	18.7732	1
19	-41.2130	456.4942	13.1012	1
20	-37.5119	464.0041	6.8253	1
21	-34.5237	471.8264	0.0000	1

SAFETY FACTORS

FOR G=0 G=0.05

			POOL ELEVATIONS	
AC	-2.148	-1.787	395.00	USED R STRGH BELOW CR WATER
SD	-212.481	-169.459	450.00	480.00 SATURATED TO SHELL
PP	-2.148	-1.787	410.00	
PP	-1.588	-1.295	437.59	
PP	-1.585	-1.270	443.29	
PP	-1.642	-1.285	449.00	
CP	-1.579	-1.276	440.70	

Figure 35. Display resulting from arc analysis using
RU AR command

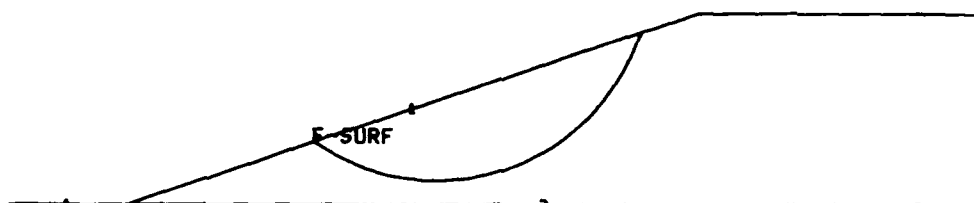


Figure 36. Display of failure surface from arc analysis
using RU AR command

*LIST DGSL

100 DATA FOR DGSLOPE

110 SOIL

120 125.,30.,0.,30.,0.,30.,0

130 -300.,400.,-250.,400.,-10.,480.,110.,480.

140 SO

150 120.,10.,3000.,10.,3000.,10.,3000.

160 -250.,400.,

170 100.,400.

180 NE

190 -150.,400.,50.,400.,1

200 PO

210 395.,410.,480.,450.,480.,450.

*

Figure 37. Building a data file for DGSLOPE

shows the terminal commands and the file entries that are necessary to prepare and save the new data file named RES for subsequent use in solving the problem shown in Figures 18 and 19. Note that had the file been previously established OLD would have been used instead of NEW and RESAVE instead of SAVE. OLD data files which were used for the slope stability programs SSW028, SSW039A, and SSA003 are still valid for DGSLOPE.

56. Note that the first line in the file must contain the title. The commands are on a line by themselves. They are followed by the required data on the next line or lines. For instance, line 110 contains the command S0 for soil data input. This is followed, on line 120, by the soil properties and, on line 130, by the soil profile. Although this profile is recorded on one line, it could just as well have been recovered on two or more lines as was done for the second soil profile (lines 160 and 170).

Drum Plots

57. Creation of drum plots is accomplished by using the "Level 2" commands:

```
RE - RETURN
ST - STOP
TE - TEKLOT
DR - DRUMLOT
IN - INITIALIZE
EN - ENTER TABLES
DI - DISPLAY TABLES
WI - WINDOW DISPLAY
CH - CHANGE XXXXX
ED - EDIT SOIL NUMBERS
```

These commands allow the user to select the desired information to be displayed on the drum plots. All drum plots are 42 in. long and 21 in. high.

Initialization Command = IN

58. The initialization phase is automatically entered when entering the drum plot portion of DGSLOPE. However, this phase can be re-entered during any part of the creation of drum plots. The initialization

portions allow selection of the desired analysis (Figure 38) to be displayed on the drum plots.

```
ENTER UP TO 10 ANALYSES TO BE PLOTTED.  
THERE ARE 3 ANALYSES STORED.  
ENTER A 0 FOR CURRENT LISTING.  
-0  
ANALYSIS - 1  
AC  
FACTOR OF SAFETY - 3.09  
ANALYSIS - 2  
SD  
FACTOR OF SAFETY - 1.92  
ANALYSIS - 3  
PP  
FACTOR OF SAFETY - 2.44  
ENTER UP TO 10 ANALYSES TO BE PLOTTED.  
THERE ARE 3 ANALYSES STORED.  
ENTER A 0 FOR CURRENT LISTING.  
-1
```

Figure 38. Display resulting
from IN command

Editing of Soil Numbers Command = ED

59. Each line segment is numbered with its corresponding soil type. However, even though this is informative, it does not always result in a desired graphic. The ED command allows the user to move or delete the soil numbers to generate a picture describable to him.

60. When the ED command is entered, the screen is erased and the soil profiles and soil numbers are displayed. The cross hairs then appear on the screen. The valid characters are:

E - End Editing
M - Move Number
D - Delete Number

A soil number can be deleted by placing the cross hairs over it and entering the character D. A soil number can be moved by placing the cross hairs over it and entering M. The cross hairs then reappear. The user places the cross hairs at the desired location for the soil number and enters any character. This process continues until the character E is entered. Figure 39 is a plot of an edited soil profile.

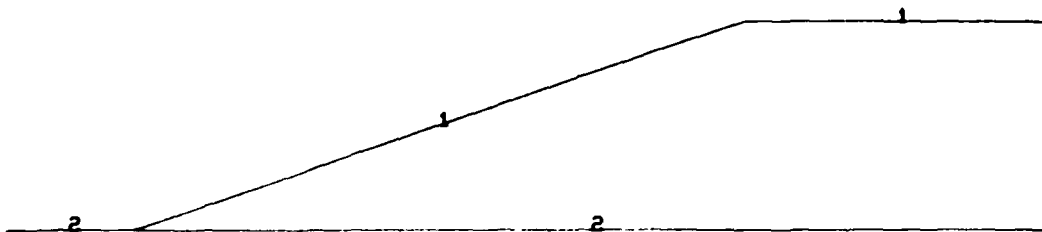


Figure 39. Display of an edited soil profile

TEKLOT Command = TE

61. The TE command is used to redisplay the drum plot on the screen after some editing has taken place. Figure 40 depicts a drum plot on the screen.

Enter Table Command = EN

62. The EN command results in a block representing the soil data

ENTER COMMAND (LEVEL TWO)

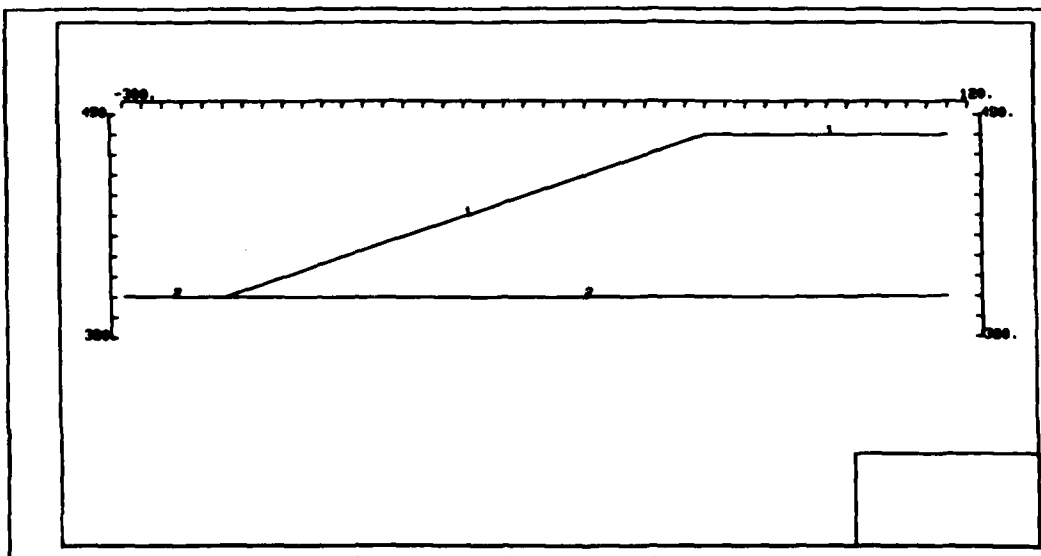


Figure 40. Display of a drum plot

table and a block for either a wedge data table or an arc data table, depending on the type of analysis chosen at Level 1 (Figure 41).

Display Tables Command = DI

63. The DI command displays the contents of the table entered by the EN command (Figure 42).

WINDOW Command = WI

64. This command is used to enlarge a portion of the soil data. When the WI command is given, the screen is erased and only soil profile data are displayed. The cross hairs then appear. The valid characters are:

W - Window
T - Total Plot
C - Continue

ENTER COMMAND (LEVEL TWO)
-EN

ENTER COMMAND (LEVEL TWO)
.

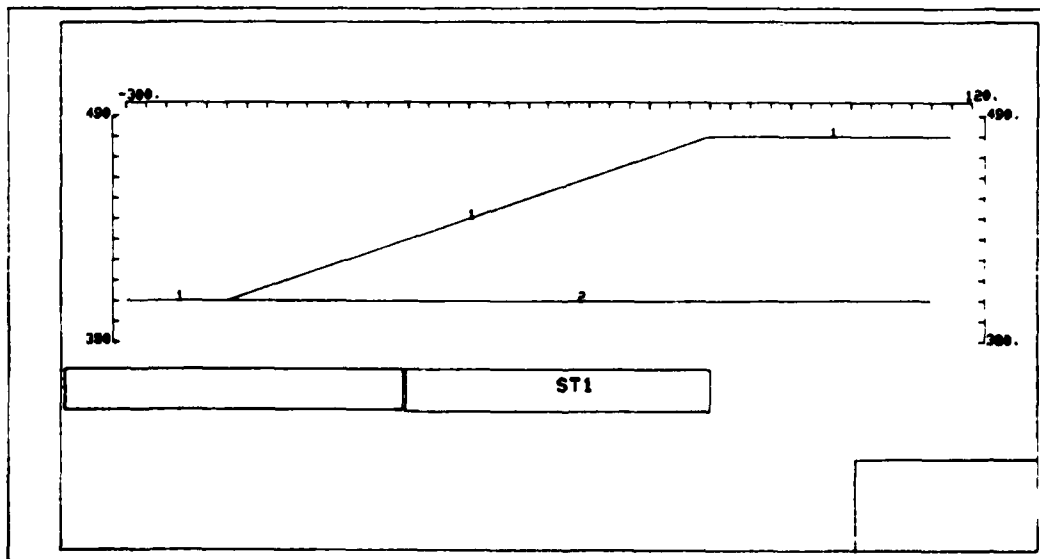


Figure 41. Display resulting from EN command

SOIL	UNIT WEIGHT	Q TEST		R TEST		S TEST	
		ANGLE	CONSTANT	ANGLE	CONSTANT	ANGLE	CONSTANT
1	125.00	30.00	0.	30.00	0.	30.00	0.
2	150.00	45.00	5000.00	45.00	5000.00	45.00	5000.00

NO.	XL	XR	YR	RA	RB	RP	DR	DP	SUM-R	SUM-D	TYPE	SF
1	-150.0	0.	400.0	22313	204095	124194	49552	-399999	350603	-350447	AC	3.09

Figure 42. Display resulting from DI command

When W is entered, the user must move the cross hairs to the lower left-hand corner, enter any character, move the cross hairs to the upper right-hand corner, and then enter any character. The screen is erased and the data within the window are displayed. A enlarged portion of the soil data resulting from the WI command is shown in Figure 43. Entering character T will result in a display of the entire data. The character C returns the user to the "Level 2" commands.

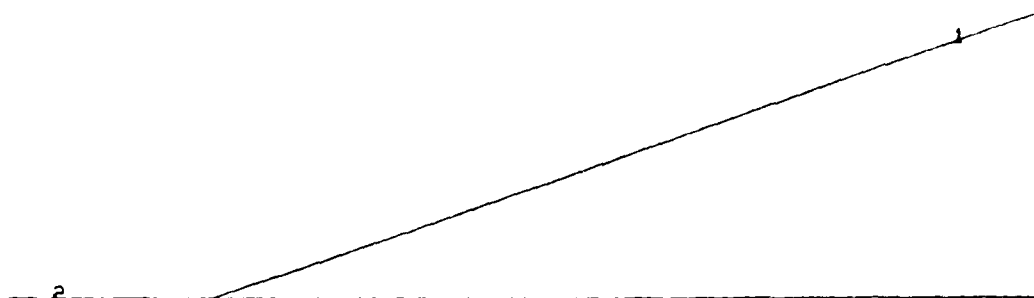


Figure 43. Display resulting from WI command

Change Soil Table Command = CH SO

65. The location of the soil table on the plot can be changed with the CH SO command. The CH SO command results in the display of the cross hairs. The user can then move the cross hairs to a new location (from the bottom left-hand corner of the soil table). The user can enter any character to place the table in a new corner.

Change Wedges Table Command = CH WD

66. The CH WD command changes the location of the wedge data table on the plot and results in the display of the cross hairs. The user can then move the cross hairs to a new location from the bottom left-hand corner of the wedge data table. The user can enter any character

to place the table in the new corner.

Change Arc Table Command = CH AR

67. The CH AR command is similar to the CH SO and CH WD commands, except that it applies to the arc data table.

Change Tic Interval Command = CH TI

68. This command results in the following:

"Enter New Distance Between Tic Marks"

=

This allows the user to control the placement of the tic marks on the drum plot.

Return Command = RE

69. The command RE returns the user to the "Level 1" commands.

Stop Command = ST

70. The ST command stop the program.

Drum Plot Command = DR

71. The DR command results in a series of questions that must be answered in order to generate a drum plot. An example using the DR command and the resulting series of questions is shown in Figure 44.

```
ENTER COMMAND (LEVEL TWO)
-DR
ENTER IDENT CARD INFORMATION
FOR MES: USERID,NAME
FOR MACON: ACCOUNT NUMBER,NAME,USERID
-1000RO,MP,11ROKASLP
INPUT STATION CODE FOR OUTPUT (00 IF NOT REMOTE)
-RO
ARE CALCOMP ROUTINES ON SYSTEM LIBRARY (YES OR NO)?
FOR MES: YES
FOR MACON: NO
-NO
ENTER LIBRARY WHERE CALCOMP ROUTINES ARE STORED
FOR MACON: 11ROKPLIB/UESTARL
-11ROKPLIB/UESTARL
ENTER LOCATION TO WHICH YOUR PLOT SHOULD BE SENT
-ADP,MES
INPUT PRIORITY (5 OR 40)
-5
SHUMB-1928G
```

Figure 44. Display resulting from DR command

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Hall, Robert L.

User's guide : interactive computer graphics slope stability package with drum plot capabilities (DGSLOPE) : final report / by Robert L. Hall, Paul K. Senter (Automatic Data Processing Center, U.S. Army Engineer Waterways Experiment Station). -- Vicksburg, Miss. : The Station ; Springfield, Va. : available from NTIS, [1981].

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Hall, Robert L.

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Station. Automatic Data Processing Center. IV. Title V. Series: Instruction report (U.S. Army Engineer Waterways Experiment Station) ; K-81-8.
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