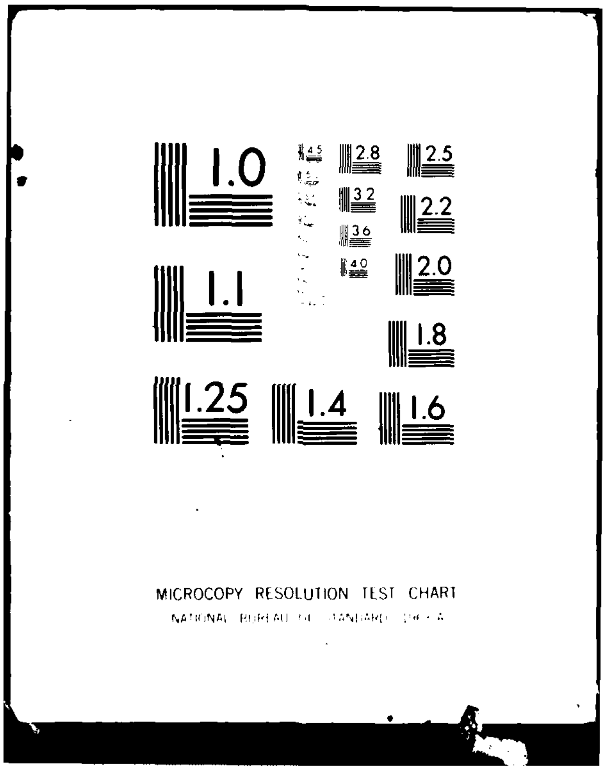
AD-A099 519 ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS F/G 13/13
USER'S GUIDE. COMPUTER PROGRAM FOR DESIGN AND ANALYSIS OF SHEET--ETC(U)
MAR 81 M E GEORGE
UNCLASSIFIED WES-INSTRUCTION-K-81-2 NL

1 OF 1
AD A099519

END
DATE FILMED
7-81
DTIC


1.0
4.5
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6
MICROCOPY RESOLUTION TEST CHART

INSTRUCTION REPORT K-81-2

USER'S GUIDE: COMPUTER PROGRAM FOR DESIGN AND ANALYSIS OF SHEET PILE WALLS BY CLASSICAL METHODS (CSHTWAL)

Report 2

INTERACTIVE GRAPHICS OPTIONS

by

Michael E. George

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

March 1981

Report 2 of a Series

A report under the Computer-Aided Structural Engineering (CASE) Project

Prepared for Office, Chief of Engineers, U. S. Army
Washington, D. C. 20314

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314

REPLY TO ATTENTION OF:
DAEN-CWE-DS

23 February 1981

SUBJECT: Instruction Report K-81-2, User's Guide: Computer Program for Design and Analysis of Sheet Pile Walls by Classical Methods (CSHTWAL), Report 1 and Report 2

All Corps Elements with Civil Works Responsibilities

1. The subject user's guide documents a computer program named CSHTWAL that can be used for analyzing and designing cantilever and singly anchored sheet pile walls. The program specification for CSHTWAL was developed by the Computer-Aided Structural Engineering (CASE) Task Group for Pile Structures and Substructures. As is the goal with all CASE tasks, the intent is to make an organized, cost-effective computer solution available to the Corps' designers for use when the need arises.

2. Engineers will be readily able to tell by the description of the program and by the examples given in the report of the applicability toward their needs. Detailed documentation of the program may be obtained from the Engineering Computer Programs Library (ECPL) of the U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, MS.

3. We strongly encourage the use of these programs where applicable throughout the Corps.

FOR THE CHIEF OF ENGINEERS:

LLOYD A. DUSCHA
Chief, Engineering Division
Directorate of Civil Works

PROGRAM INFORMATION

Description of Program

CSHTWAL, called X0031 in the Conversationally Oriented Real-Time Program-Generating System (CORPS) library, performs design and/or analysis of either a cantilever or an anchored sheet pile wall. The program uses classical soil mechanical procedures for determining the required depth of penetration of a new wall or assesses the factor of safety for an existing wall. Seepage effects are included in a simplified manner in the program.

Coding and Data Format

CSHTWAL is written in FORTRAN and is operational on the following systems:

a. U. S. Army Engineer Waterways Experiment Station (WES) Honeywell G635.

b. Office of Personnel Management Honeywell 6000 Series at Macon, Ga.

c. Boeing Corporation's CDC CYBER 175.

Data can be input either interactively from the user's terminal or from a prepared data file with line numbers. When data are input from the terminal during execution, the program provides prompting messages to indicate the type and amount of input data to be provided. Output can be obtained at the terminal, written to a permanent file for listing at the terminal at a later date, or directed to a mainframe line printer. The program also has interactive graphics capabilities to allow the user to display the input geometry with applied loads and/or the output including moment, shear, deflection, and pressure diagrams.

How To Use CSHTWAL

A short description of how to access the program on each of the three systems is provided below. It is assumed that the user knows how to sign on the appropriate system before trying to use CSHTWAL. In the example initiation of execution commands below, all user responses are underlined, and each should be followed by a carriage return.

WES G635 and Macon systems

After the user has signed on the system, the two system commands FORT and NEW get the user to the level to execute the program. Next, the user issues the run command

RUN WESLIB/CORPS/XØØ31,R

to initiate execution of the program. The program is then run as described in this user's guide. The data file should be prepared prior to issuing the RUN command. An example of initiation of execution is as follows, assuming a data file had previously been prepared:

HIS SERIES 6ØØ ON Ø9/18/8Ø AT CHANNEL 5647
USER ID - RØKAGASESHT
PASSWORD - [redacted]
SYSTEM? FORT NEW
READY
*RUN WESLIB/CORPS/XØØ31,R

Boeing system

The log-on procedure is followed by a call to the CORPS procedure file

OLD,CORPS/UN=CECELB

to access the CORPS library. The file name of the program is used in the command

CALL,CORPS,XØØ31

to initiate execution of the program. An example is:

WELCOME TO THE BCS NETWORK
YOUR ACCESS PORT IS SWY 55
SELECT DESIRED SERVICE: EKS1
8Ø/Ø9/18. 13.3Ø.Ø.
EKS1 175G.NØ46Ø.68BA 8Ø/Ø9/14.DS-Ø Ø2.39.Ø5. 8Ø/Ø9/16.
USER ID: CERØC1
PASSWORD -
[redacted]

(Continued)

```
*
C>OLD,CORPS/UN=CECELB
C>CALL,CORPS,XØØ31
```

How To Use CORPS

The CORPS system contains many other useful programs which may be catalogued from CORPS by use of the LIST command. The execute command for CORPS on the WES and Macon systems is:

```
RUN WESLIB/CORPS/CORPS,R
ENTER COMMAND (HELP,LIST,BRIEF,MESSAGE,EXECUTE, OR STOP)
*?LIST
```

on the Boeing system, the commands are:

```
OLD,CORPS/UN=CECELB
ENTER COMMAND (HELP,LIST,BRIEF,MESSAGE,EXECUTE, OR STOP)
*?LIST
```

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
Instruction Report -81-2

2. GOVT ACCESSION NO.
AD-A099 519

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
USER'S GUIDE: COMPUTER PROGRAM FOR DESIGN AND ANALYSIS OF SHEET PILE WALLS BY CLASSICAL METHODS (CSHTWAL); Report 2, Interactive Graphics Options

5. TYPE OF REPORT & PERIOD COVERED
Report 2 of a series

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
Michael E. George

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
U. S. Army Engineer Waterways Experiment Station
Automatic Data Processing Center
P. O. Box 631, Vicksburg, Miss. 39180

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
Office, Chief of Engineers, U. S. Army
Washington, D. C. 20314

12. REPORT DATE
March 1981

13. NUMBER OF PAGES
80

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

This report was prepared under the Computer-Aided Structural Engineering (CASE) Project. A list of published CASE reports is printed on the inside of the back cover.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computer graphics
Computer programs
CSHTWAL (Computer program)
Sheet piling
Steel sheet piles

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This user's guide describes the interactive graphics options of computer program "CSHTWAL." CSHTWAL can be used for design and analysis of sheet pile walls using classical methods. The graphics capabilities allow the user to interactively display the input geometry with applied loads and/or the output including moment, shear, deflection, and pressure diagrams. A Tektronix 4014/4054 graphics terminal is required to use these capabilities.

Use of CSHTWAL itself is discussed in detail in Report 1 of this series.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Preface

This user's guide presents documentation of the interactive graphics options of computer program "CSHTWAL." CSHTWAL can be used for the design and analysis of sheet pile walls using classical methods. The work in writing the interactive graphics options for the program and this user's guide was accomplished with funds provided to the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., by the Office, Chief of Engineers, U. S. Army (OCE), under the Computer-Aided Structural Engineering (CASE) Project.

Specifications for CSHTWAL were provided by members of the CASE Task Group on Sheep Pile Structures. The following were members of the Task Group (though all may not have served for the entire period) during the period of development of the program:

Mr. Terry Soupos, North Central Division (Chairman)
Mr. Richard Albert, Detroit District
Mr. James Bigham, New Orleans District
Mr. Walter Green, Nashville District
Mr. Tom McGee, Nashville District
Mr. Louis Mendell, New York District
Mr. T. Samuelson, Seattle District
Mr. Ken Waddell, Huntington District

During the latter stages of development of the program and this user's guide, the Sheet Pile Structures Task Group was combined with the Pile Foundations Task Group and renamed the Pile Structures and Sub-Structures Task Group. This new Task Group then assumed responsibility for the program. The Pile Structures and Sub-Structures Task Group is composed of the following members:

Mr. James Bigham, New Orleans District (Chairman)
Mr. Roger Brown, South Atlantic Division
Mr. Dick Chun, Pacific Ocean Division
Mr. Walter Green, Nashville District
Mr. Joe Hartmann, St. Louis District
Mr. Roger Hoell, St. Louis District
Mr. Tom Mudd, St. Louis District (former Chairman)
Mr. Phil Napalitano, New Orleans District
Mr. Arthur Shak, Pacific Ocean Division
Mr. Ralph Strom, Portland District

Documentation of CSHTWAL itself is provided in WES Instruction Report K-81-2, "User's Guide: Computer Program for Design and Analysis of Sheet Pile Walls by Classical Methods (CSHTWAL); Report 1: Computational Processes," by William P. Dawkins. The interactive graphics options and this user's guide were written by Mr. Michael E. George, Research and Development Software Group, Automatic Data Processing (ADP) Center, WES. Appendix A to this user's guide and the example presented in Appendix B are from Report 1.

Dr. N. Radhakrishnan, Special Technical Assistant, ADP Center, WES, and CASE Project Manager, coordinated and monitored the work with assistance provided by Mr. Paul K. Senter, Computer-Aided Design Group (CADG), ADP Center. Mr. H. Wayne Jones, CADG, supported the Task Group in compiling program specifications. He and Ms. Dorothy B. May, CADG, helped in converting the program to the WES, Macon, and Boeing computers. Messrs. Donald M. Dressler and Rixby Hardy, Civil Works Directorate, were OCE points of contact. Mr. Donald L. Neumann was Chief of the ADP Center during the development of the program and preparation of this user's guide.

Directors of WES during this period were COL J. L. Cannon, CE, and COL N. P. Conover, CE. Technical Director was Mr. F. R. Brown.

Contents

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:

Multiply	By	To Obtain
feet	0.3048	metres
inches	2.54	centimetres
kip (1000 lb force)-feet	1.355818	kilonewton-metres
pound (force)-feet	1.355818	newton-metres
pound (force)-inches	0.1129848	newton-metres
pounds (force)	4.448222	newtons
pounds (force) per square foot	47.88026	kilopascals
pounds (force) per square inch	6.894757	kilopascals
pounds (mass) per cubic foot	16.01846	kilograms per cubic metre
pounds (mass) per foot	1.488164	kilograms per metre

USER'S GUIDE: COMPUTER PROGRAM FOR DESIGN AND ANALYSIS OF SHEET PILE WALLS BY CLASSICAL METHODS (CSHTWAL)

INTERACTIVE GRAPHICS OPTIONS

Introduction

1. This user's guide describes the interactive graphics options of computer program "CSHTWAL." CSHTWAL can be used for design and analysis of sheet pile walls using classical methods. The graphics capabilities allow the user to interactively display the input geometry with applied loads and/or the output including moment, shear, deflection, and pressure diagrams. A Tektronix 4014/4054 graphics terminal is required to use these capabilities.

2. Use of CSHTWAL itself is discussed in detail in Report 1 of this series.* In the remainder of this user's guide, that document will be referred to as "Report 1." This report only addresses the interactive graphics options of CSHTWAL. The input guide from Report 1 is provided again in Appendix A for easy reference.

Input Geometry

3. The user may display the input geometry in both the analysis and the design modes for either an anchored or a cantilevered wall. If any loads have been applied to the right-side soil surface or to the wall, a plot displaying these loads will also be output. If no loads are applied, only the input geometry plot will be displayed.

4. To enter the input graphics portion of the program, the user must respond with YES to the following question:

---

* Dawkins, W. P. 1981. "User's Guide: Computer Program for Design and Analysis of Sheet Pile Walls by Classical Methods (CSHTWAL); Report 1: Computational Processes," Instruction Report K-81-2, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

```
    DO YOU WANT A PLOT OF INPUT GEOMETRY?
    ENTER 'YES' OR 'NO'
=
```

5. Having answered with a YES response, the user must now enter the distances (in feet) from the left and right sides of the wall to set up the display boundary limits for the input geometry plots:

```
    ENTER DISTANCE FROM WALL TO WHICH PLOT IS DESIRED
         LEFT SIDE      RIGHT SIDE
           (FT)            (FT)
=
```

It should be pointed out that the distance from the wall on the left side need not be symmetric to the distance from the wall on the right side. However, nonsymmetric input, such as the distance from the wall on the left side = 50 ft* and on the right side = 100 ft, may cause some of the plot to be "clipped."

6. Upon entering the two values and a carriage return, the screen will be erased and the plots displayed. A bell will ring at the end of each plot, and execution will be suspended to allow the user to make a hardcopy if desired. To resume execution of the program, the user simply enters a carriage return.

7. An example of the input geometry interactive sequence is presented below. Unless otherwise stated, only the first character of the word is required whenever the program asks for a work response. The input and analysis parts of this example (problem "ANCH1" from Report 1) are shown in Appendix B.

```
    DO YOU WANT A PLOT OF INPUT GEOMETRY?
    ENTER 'YES' OR 'NO'
=YES
```

(The screen is erased.)

---

* A table of factors for converting inch-pound units of measurement to metric (SI) units is presented on page 4.

```
*** I N P U T   S E L E C T E D ***
    ENTER DISTANCE FROM WALL TO WHICH PLOT IS DESIRED
         LEFT SIDE      RIGHT SIDE
            (FT)           (FT)
=-100.,100.
```

(The screen is erased and the plot in Figure 1 is displayed. A bell rings and execution is temporarily halted so that the user can take a hardcopy.

Upon entering a carriage return, the screen is again erased. Since there is a uniform load on the right-side soil surface, the plot in Figure 2 is displayed. A bell rings suspending execution so that a hardcopy can be taken.)

8. If a carriage return is entered, the screen is erased and the user is given the opportunity to replot the input geometry and applied loads with different display boundary limits (different scale):

```
    DO YOU WANT TO REPLOT WITH NEW DISTANCES FROM WALL?
    ENTER 'YES' OR 'NO'
=
```

If the user responds with YES, he is returned to the question in paragraph 5. If he responds with NO, the input geometry sequence is exited, and he is returned to the main program to continue execution.

9. It should be noted that if the user has input any of the applied loads described in Appendix A, paragraphs 11-13, those loads will be displayed on a plot similar to that shown in Figure 2.

10. Figures 3-10 show examples of applied loads displayed with the input geometry. These plots do not correspond to any problem discussed in this report. They are used here for illustration only.

Output Results

11. The graphics options enable the user to display moments, shears, deflections, and pressures for either an anchored or a cantilevered wall. The user may also redisplay the input geometry plots

LEFTSIDE SOIL PROPERTIES

LAYER	C	PHI	GAMMA	DELTA
L1	0.	30.0	128.5	20.0

RIGHTSIDE SOIL PROPERTIES

LAYER	C	PHI	GAMMA	DELTA
R1	0.	30.0	105.0	20.0
R2	0.	30 0	128 5	20 0

PROBLEM - ANCH1 - ANCHORED WALL DESIGN - GRANULAR SOIL
FROM 'FOUNDATION ANALYSIS AND DESIGN' BY J. E. BOWLES
EXAMPLE 13-3, PP 429-431

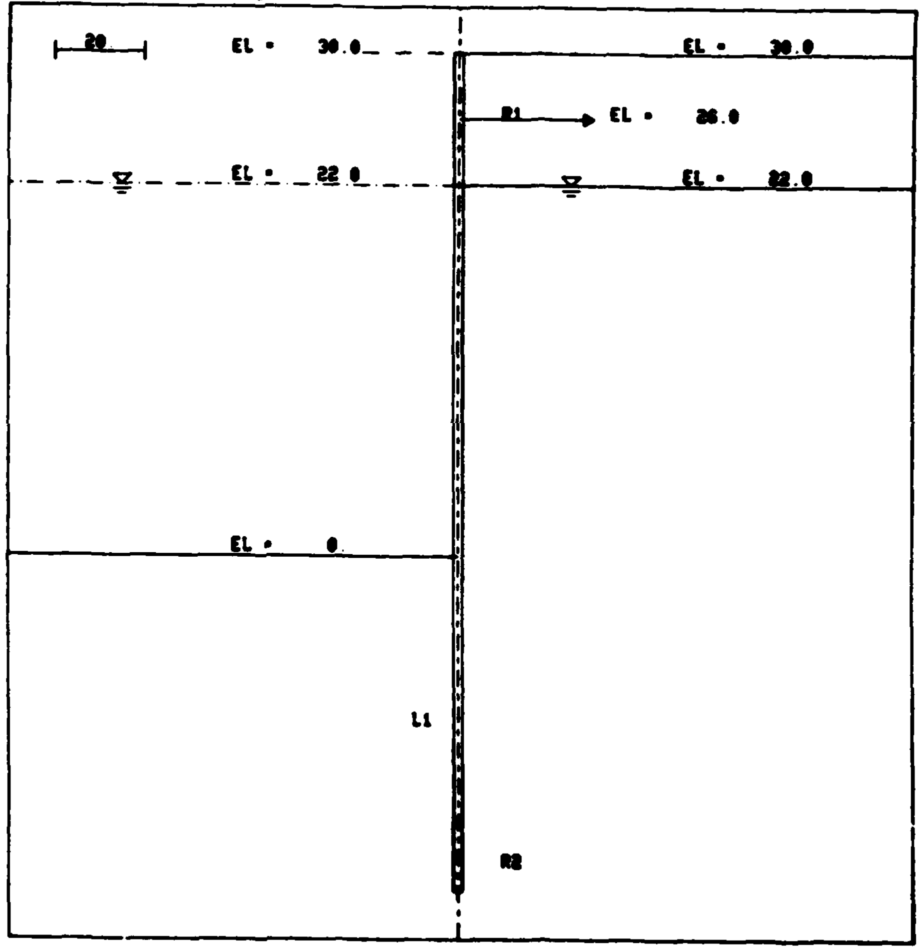


Figure 1. Input geometry plot for problem "ANCH1"

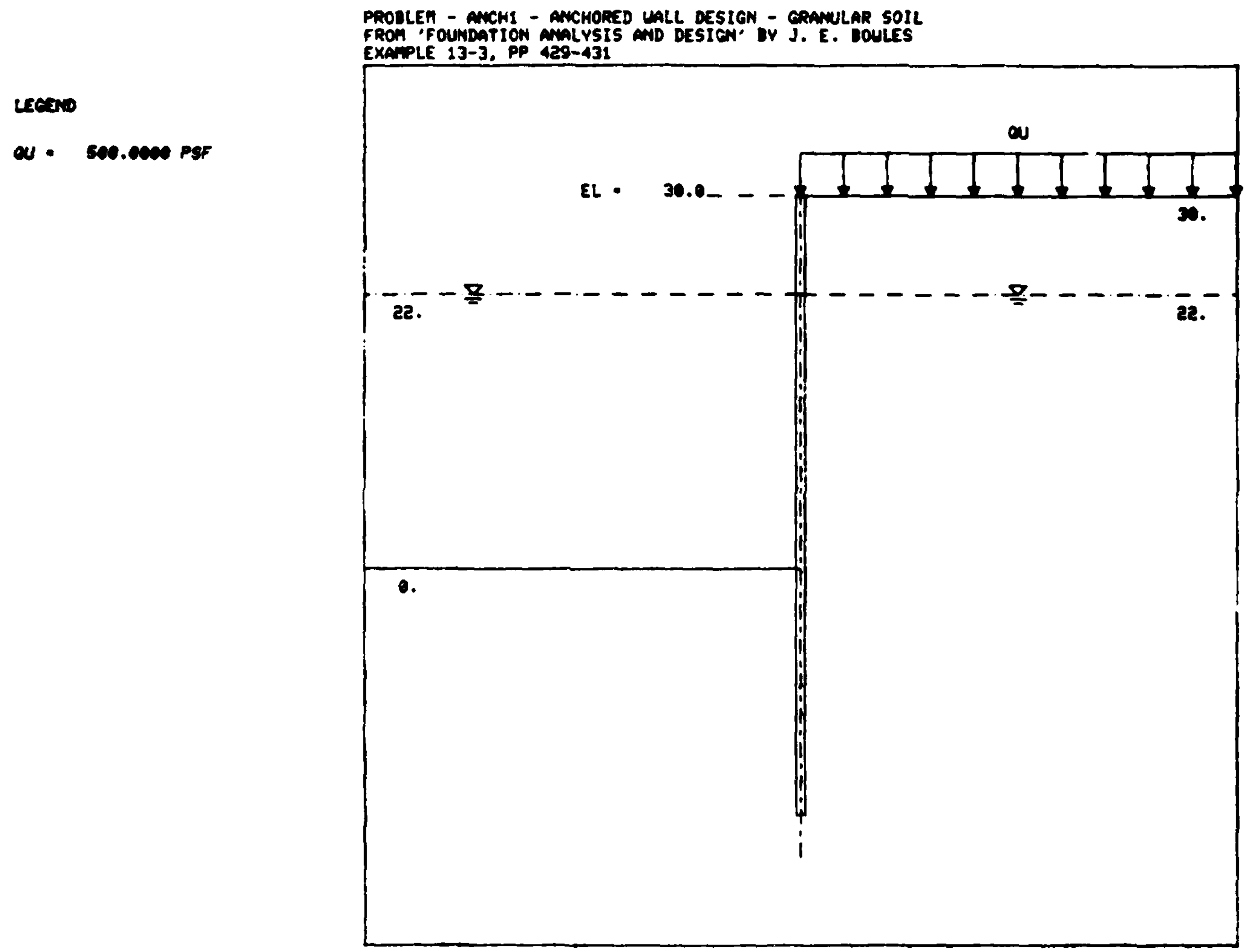


Figure 2. Input geometry with applied loads for problem "ANCH1"

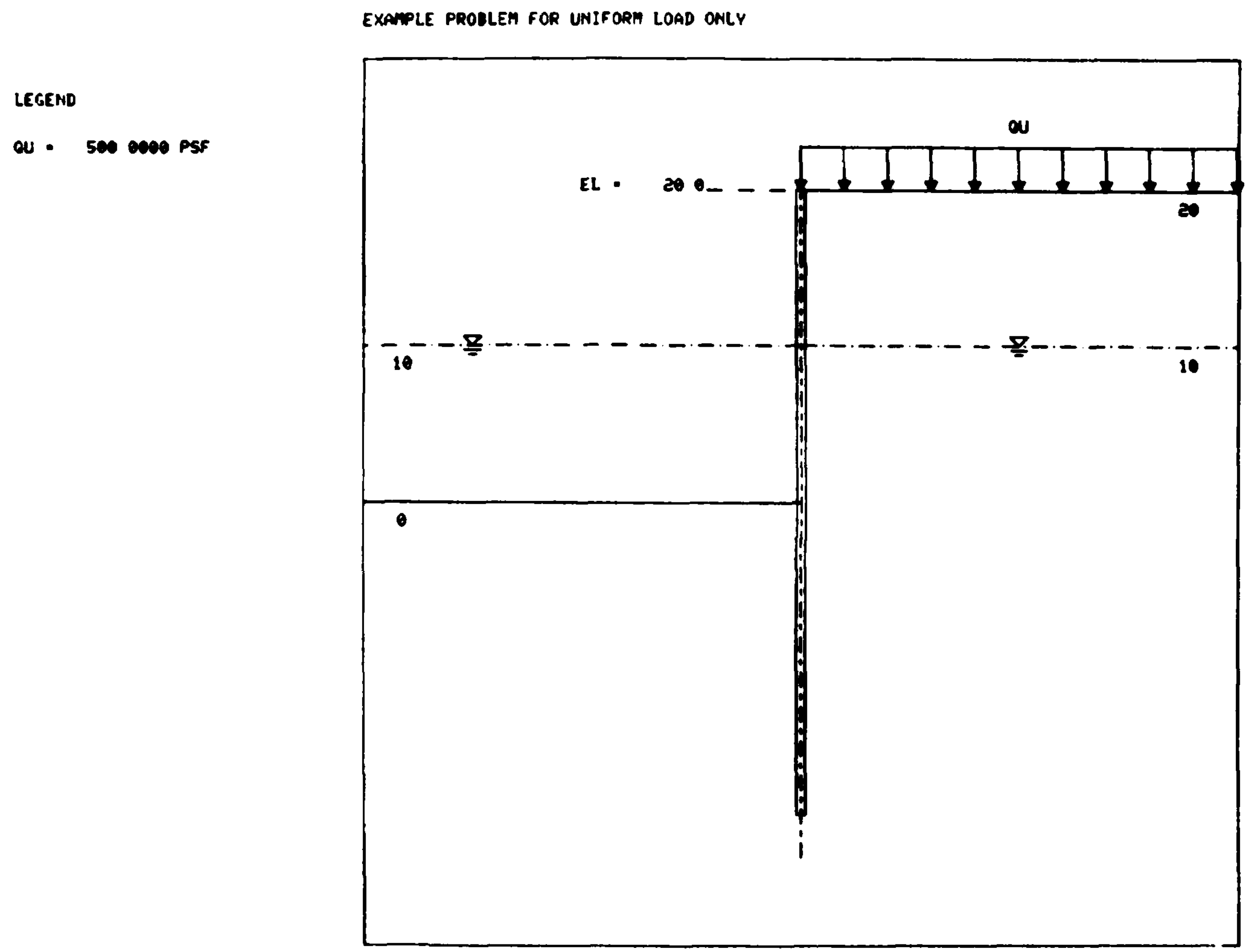


Figure 3. Example plot of uniform load on top soil surface

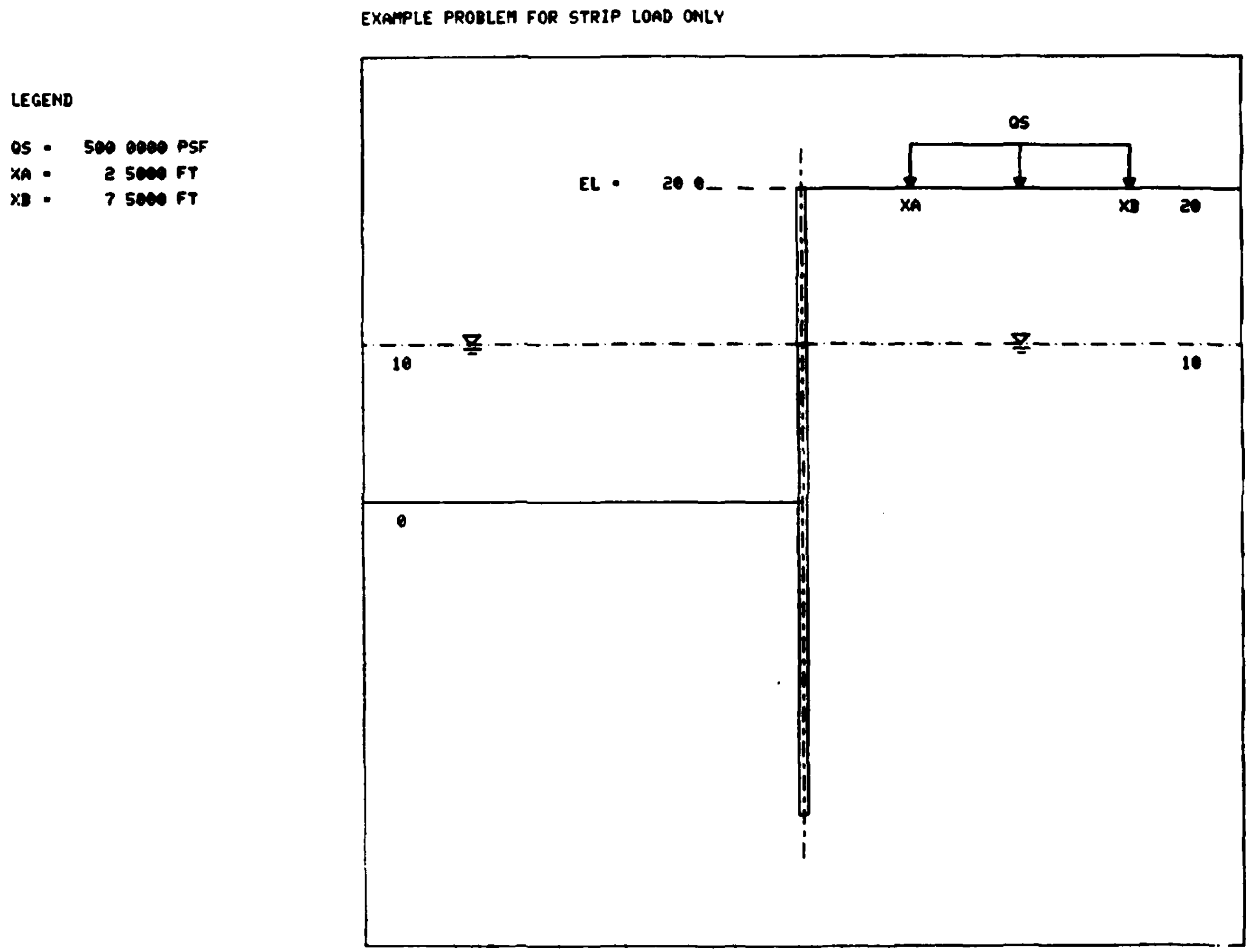


Figure 4. Example plot of strip load on top soil surface

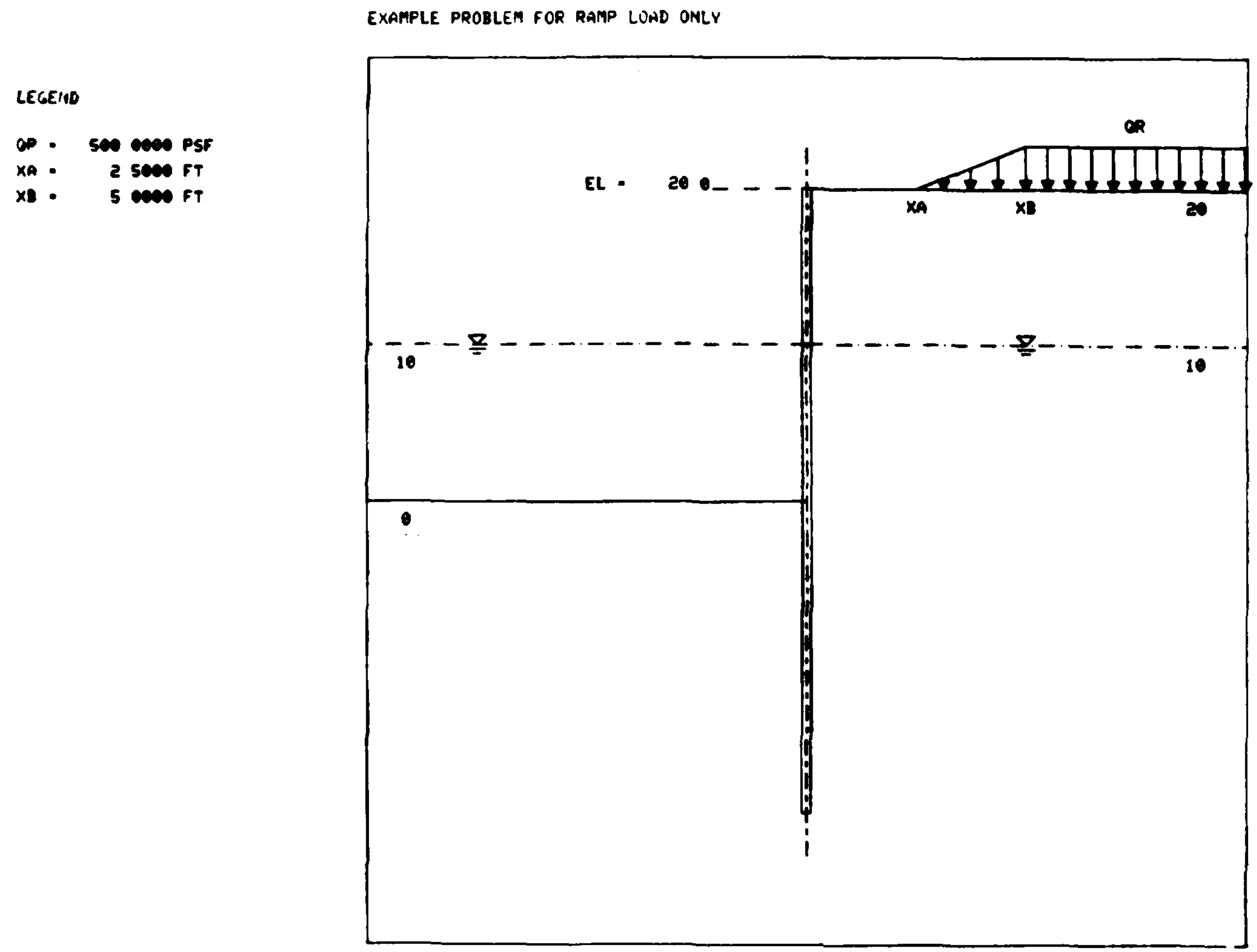


Figure 5. Example plot of ramp load on top soil surface

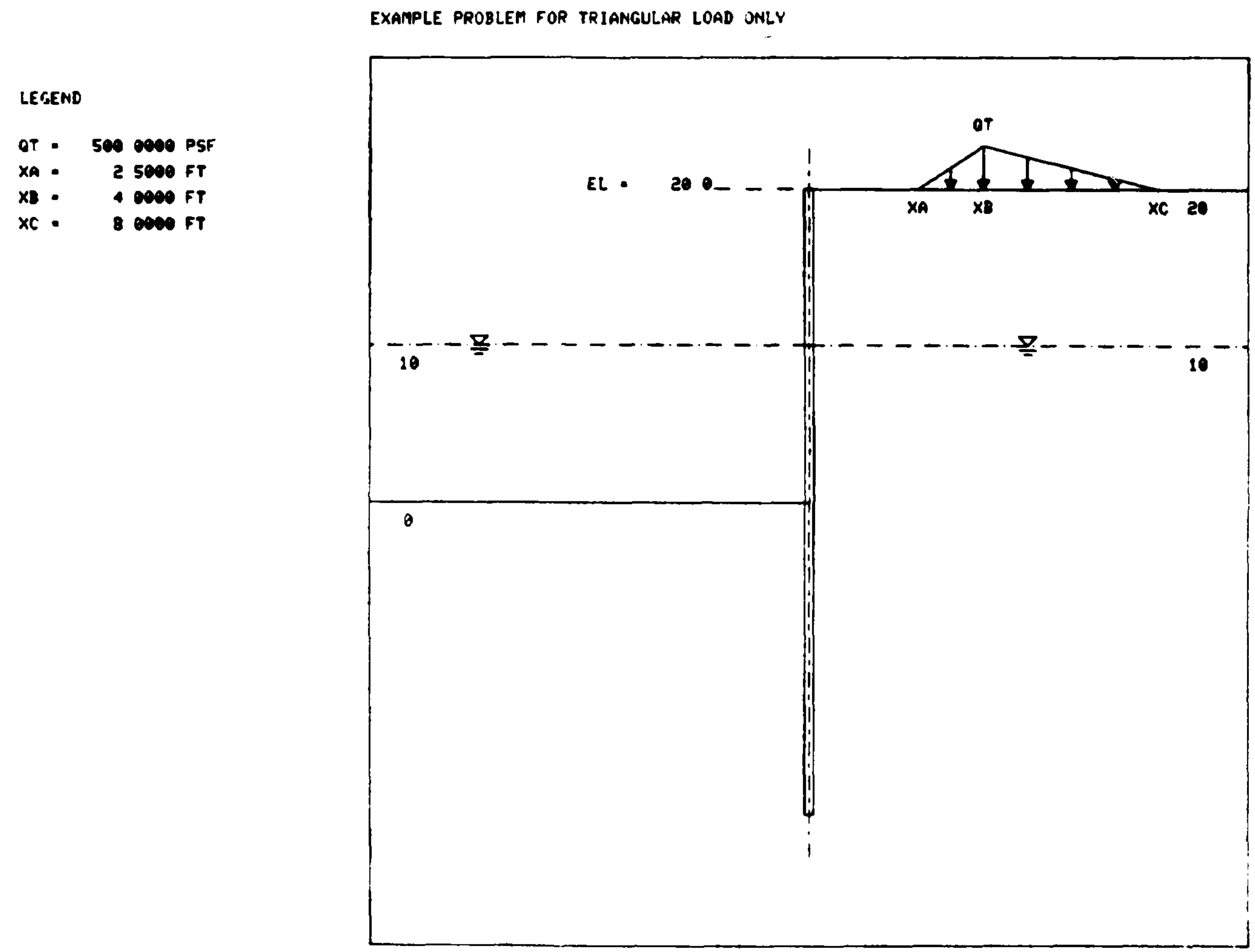


Figure 6. Example plot of triangular load on top soil surface

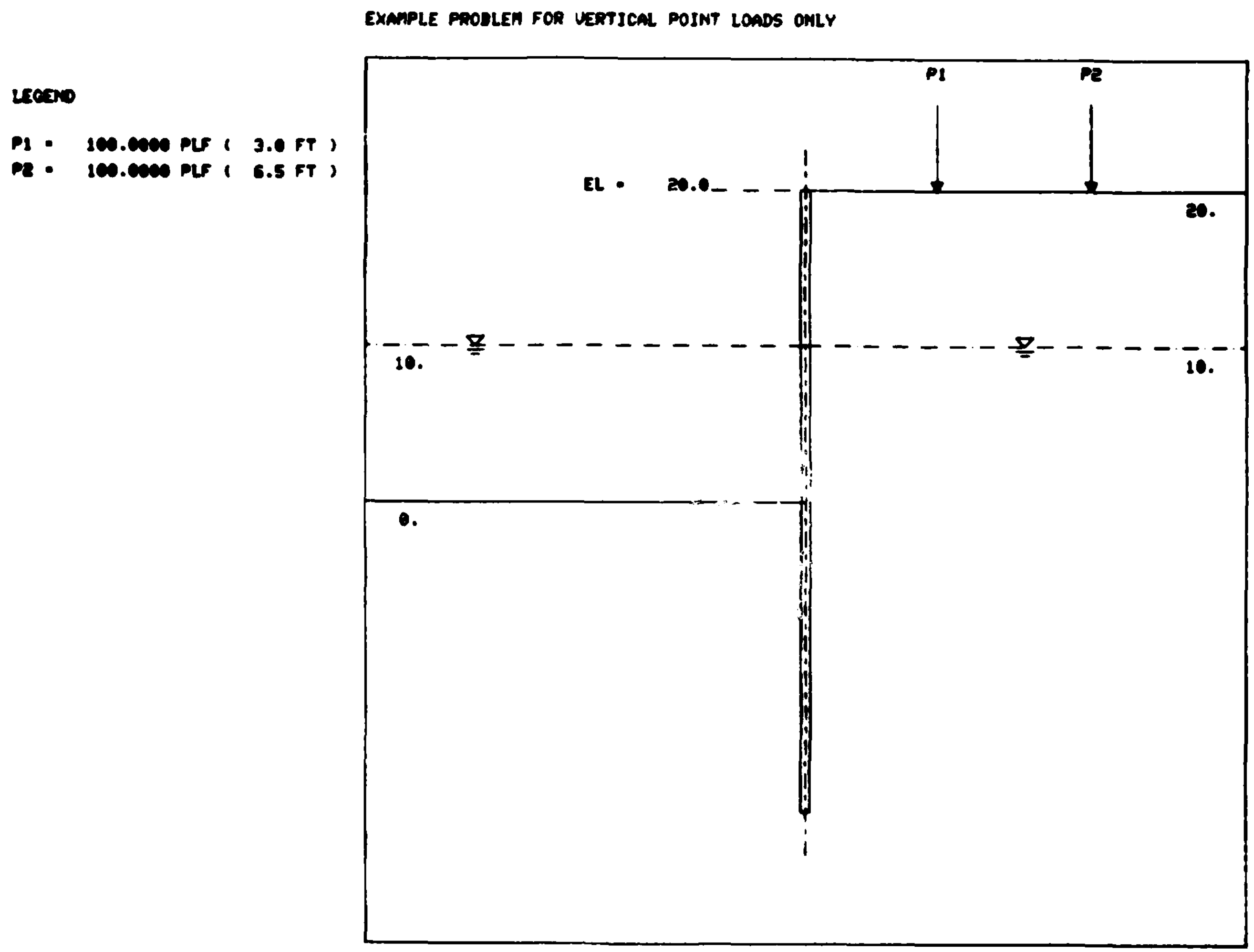


Figure 7. Example plot of vertical point loads on top soil surface

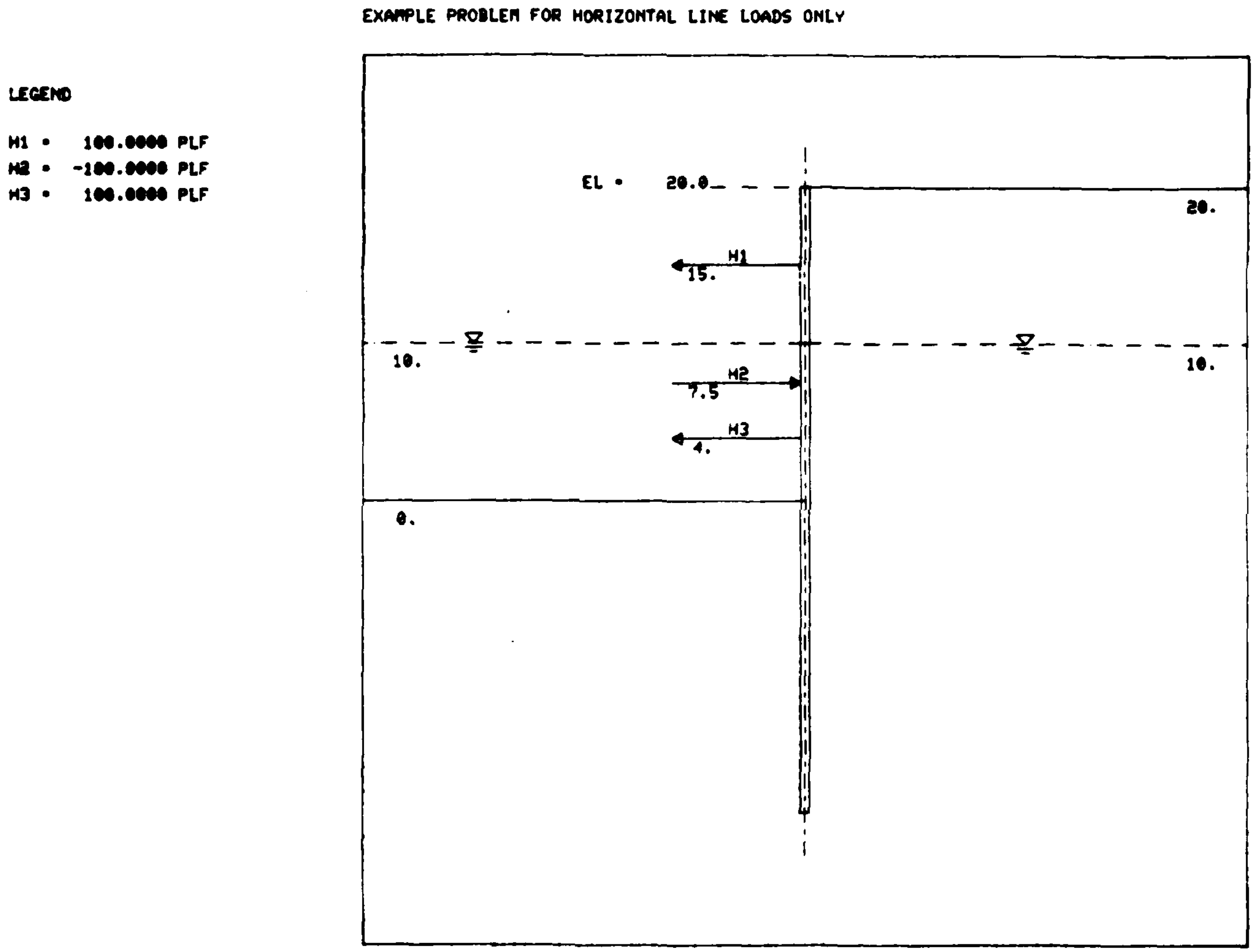


Figure 8. Example plot of horizontal line loads applied to the wall

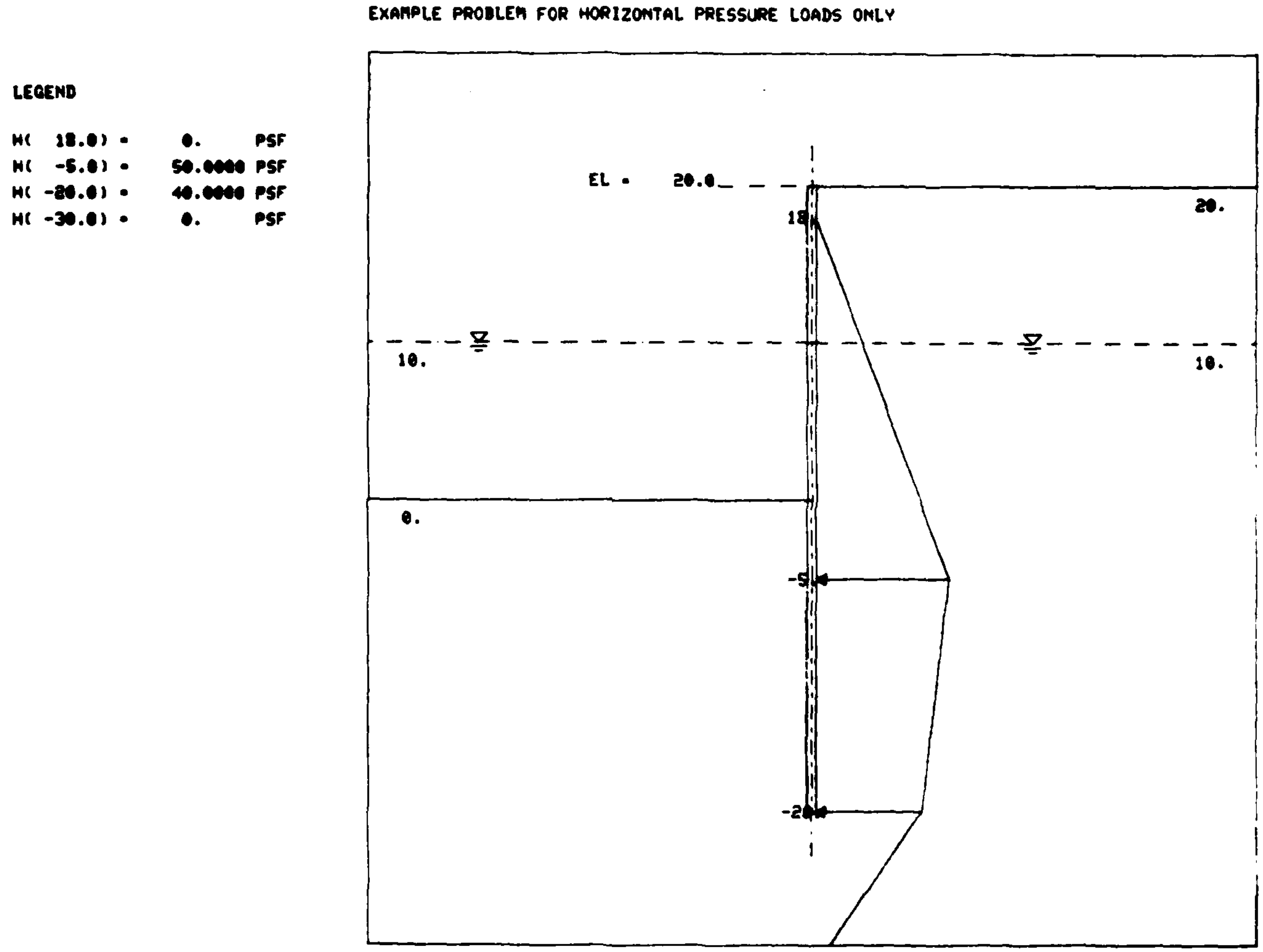


Figure 9. Example plot of horizontal pressure loads applied to the wall

EXAMPLE PROBLEM WITH 4 LOADS AND SLANTED SURFACE

LEGEND

P1 = 500.0000 PLF (7.5 FT)
P2 = 500.0000 PLF (25.0 FT)
P3 = 500.0000 PLF (42.5 FT)
QT = 200.0000 PSF
XA = 15.0000 FT
XB = 20.0000 FT
XC = 35.0000 FT
H1 = 100.0000 PLF
H2 = 100.0000 PLF
H3 = -100.0000 PLF
H(7.0) = 0. PSF
H(4.0) = 50.0000 PSF
H(-2.0) = 25.0000 PSF
H(-8.0) = 0. PSF

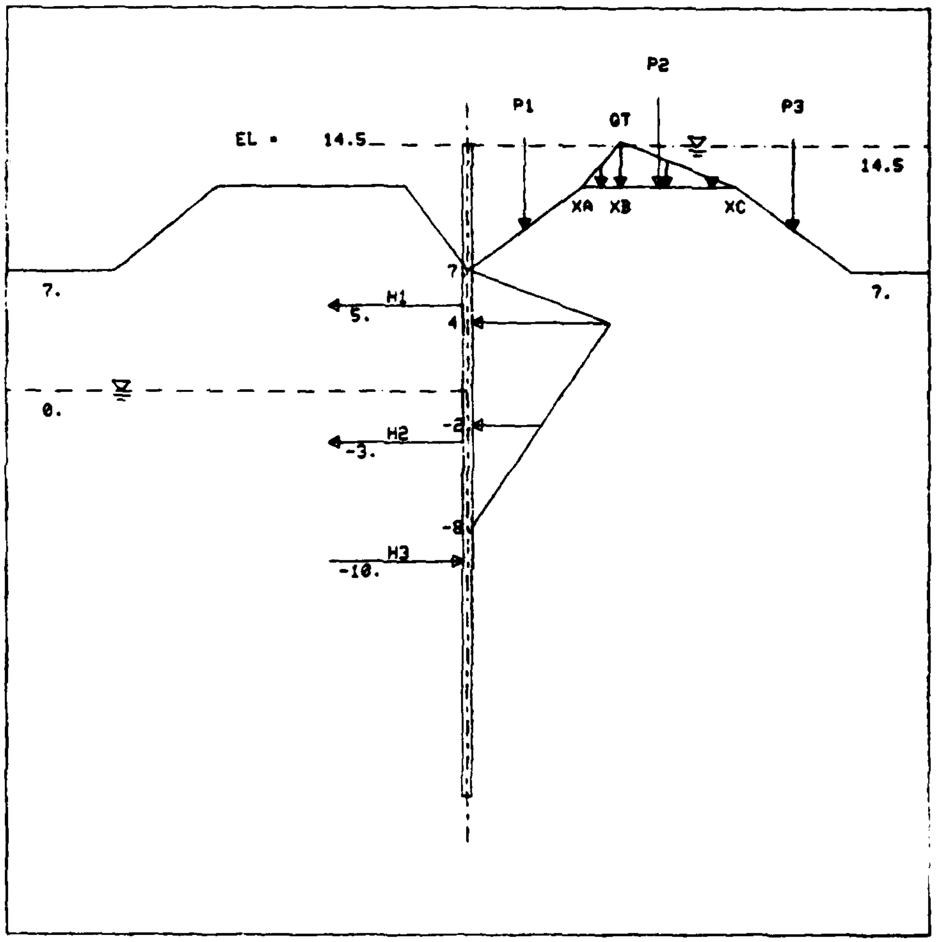


Figure 10. Example plot of multiple load applied on top soil surface and to the wall

with the bottom elevation of the wall which was calculated in the design run. For example, if the user began his problem in the design mode, the original input geometry plots will not show an elevation at the bottom of the wall. Upon completion of the solution, a bottom of the wall is defined. The user can then obtain these same input geometry plots with the bottom elevation of the wall labelled.

12. To enter the output graphics portion of the code, the user must respond to the following question:

```
    DO YOU WANT GEOMETRY AND/OR RESULTS PLOTTED?
    ENTER 'GEOMETRY', 'RESULTS', 'BOTH', OR 'NEITHER'
=
```

If the user responds with NEITHER, the output graphics sequence is omitted, and the user is returned to the main program to continue execution. If he responds incorrectly to this question, it will be repeated and he will be given another opportunity to enter a correct response. A response of BOTH or GEOMETRY gives the user the opportunity to replot his input geometry.

13. If the user is solving an anchored wall problem, he must select the desired method of analysis for which the input geometry will be displayed. The following question is asked:

```
    RESULTS ARE AVAILABLE FOR FOLLOWING METHODS OF ANALYSIS
         FREE EARTH : ENTER 'FR' ON CUE
         FIXED EARTH: ENTER 'FI' ON CUE
         EQUIV BEAM : ENTER 'EB' ON CUE
         EQUAL MOM  : ENTER 'EM' ON CUE
         TERZAGHI   : ENTER 'TE' ON CUE
    ENTER METHOD FOR WHICH GEOMETRY PLOT IS DESIRED
=
```

If the user responds incorrectly, the question will again be repeated and he will be given another opportunity to enter a correct response.

14. If the user selects a method for which results were not processed, a message will be printed stating this. For example, if the user selected the TERZAGHI method of analysis and it had not been processed, the following would be output:

```
    RESULTS ARE NOT AVAILABLE FOR METHOD 'TE'
```

15. The user is then given the opportunity to select another method:

```
    DO YOU WANT RESULTS PLOTTED FOR ANOTHER METHOD?
    ENTER 'YES' OR 'NO'
=
```

A response of YES returns the user to the question in paragraph 13. A NO response exits the output graphics sequence of the code and returns the user to the main program to continue execution.

16. When the selection of a method which has been processed is made, the same sequence of prompts discussed previously in paragraphs 4-8 will be issued.

17. If the user is solving a cantilevered wall problem, the questions discussed in paragraphs 13-15 will be omitted and only the input sequence in paragraphs 4-8 will be issued.

18. The following is an example (again for problem "ANCH1" in Appendix B) of the input geometry redisplay interactive sequence:

```
    DO YOU WANT GEOMETRY AND/OR RESULTS PLOTTED?
    ENTER 'GEOMETRY', 'RESULTS', 'BOTH', OR 'NEITHER'
=BOTH

                 (The screen is erased.)

*** I N P U T   S E L E C T E D ***
    RESULTS ARE AVAILABLE FOR FOLLOWING METHODS OF ANALYSIS
         FREE EARTH : ENTER 'FR' ON CUE
         FIXED EARTH: ENTER 'FI' ON CUE
         EQUIV BEAM : ENTER 'EB' ON CUE
         EQUAL MOM  : ENTER 'EM' ON CUE
         TERZAGHI   : ENTER 'TE' ON CUE
    ENTER METHOD FOR WHICH GEOMETRY PLOT IS DESIRED
=FR
    ENTER DISTANCE FROM WALL TO WHICH PLOT IS DESIRED
         LEFT SIDE      RIGHT SIDE
            (FT)           (FT)
=-100.,100

                 (The screen is again erased and
                 Figures 11 and 12 are displayed.
```

LEFTSIDE SOIL PROPERTIES

LAYER	C	PHI	GAMMA	DELTA
L1	0.	30.0	128.5	20.0

RIGHTSIDE SOIL PROPERTIES

LAYER	C	PHI	GAMMA	DELTA
R1	0	30.0	105.0	20.0
R2	0	30.0	128.5	20.0

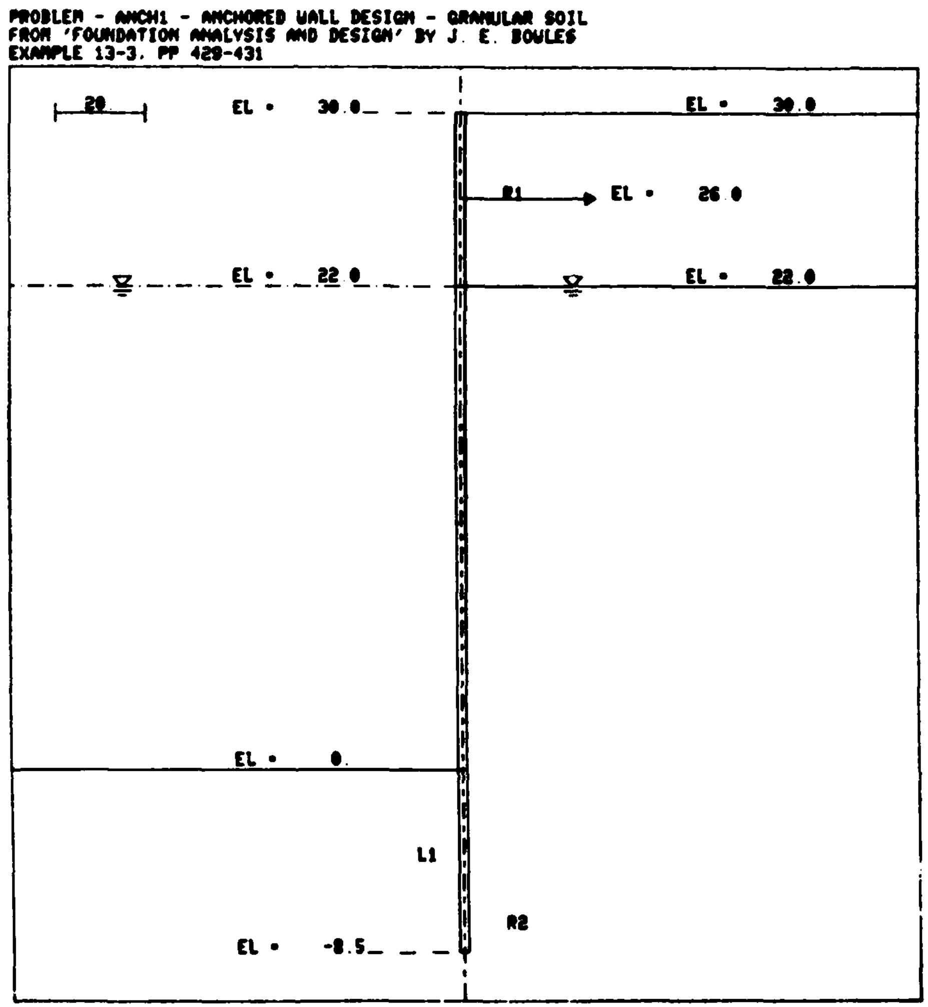


Figure 11. Input geometry redisplay for problem "ANCH1" (free earth method of analysis)

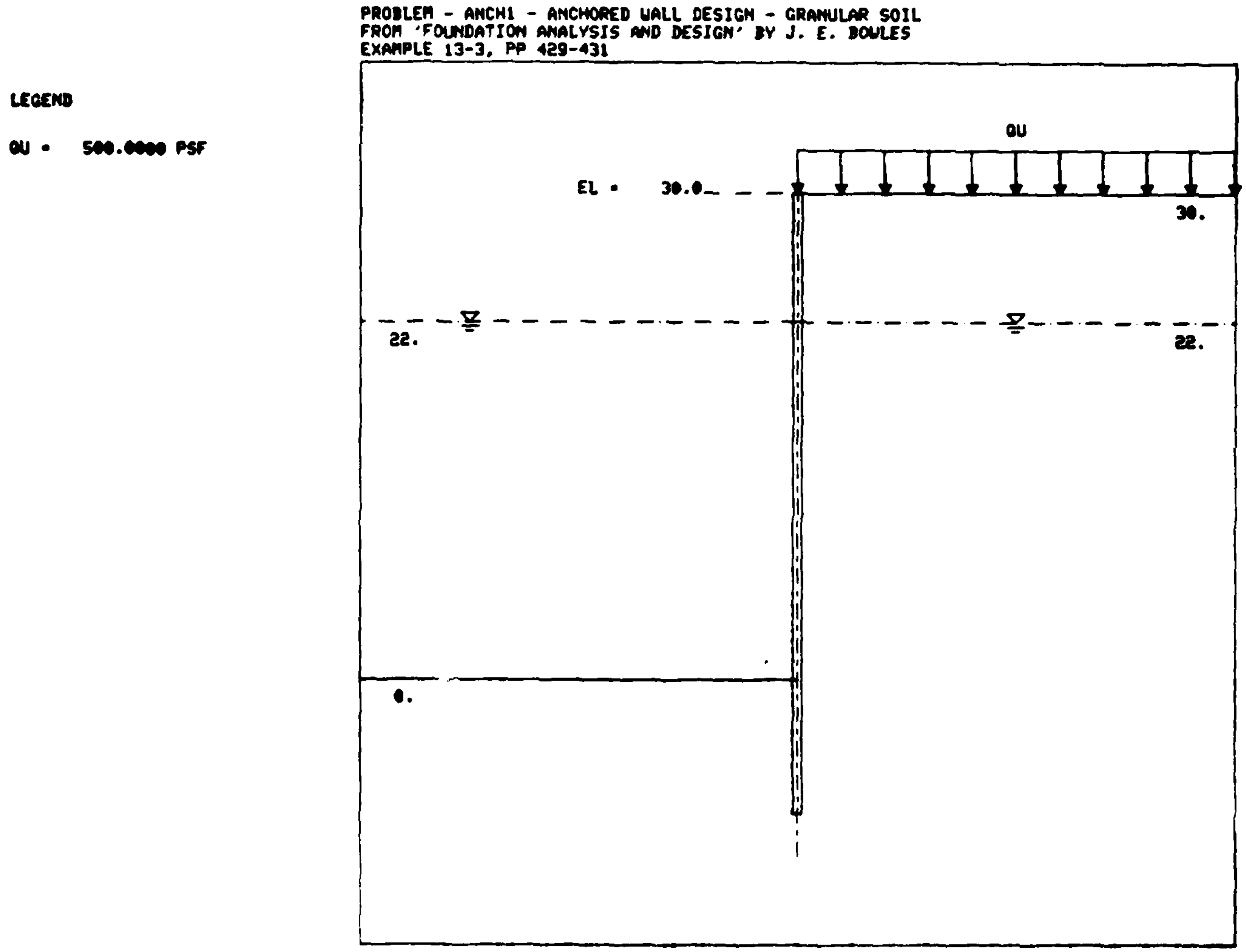


Figure 12. Input geometry applied loads redisplay for problem "ANCH1"
(free earth method of analysis)

As before, a bell rings and execution is temporarily suspended so that hardcopies can be made of each plot. To continue execution, simply enter a carriage return and the applied loads will be redisplayed. There is a pause to allow the user to make hardcopies if desired. To continue, hit the carriage return and the screen is erased and another method of analysis may be selected.)

```
    DO YOU WANT TO REPLOT WITH NEW DISTANCES FROM WALL?
    ENTER 'YES' OR 'NO'
=NO
    DO YOU WANT GEOMETRY PLOTTED FOR ANOTHER METHOD?
    ENTER 'YES' OR 'NO'
=YES
    RESULTS ARE AVAILABLE FOR FOLLOWING METHODS OF ANALYSIS
         FREE EARTH : ENTER 'FR' ON CUE
         FIXED EARTH: ENTER 'FI' ON CUE
         EQUIV BEAM : ENTER 'EB' ON CUE
         EQUAL MOM  : ENTER 'EM' ON CUE
         TERZAGHI   : ENTER 'TE' ON CUE
    ENTER METHOD FOR WHICH GEOMETRY PLOT IS DESIRED
=FI
    ENTER DISTANCE FROM WALL TO WHICH PLOT IS DESIRED
         LEFT SIDE      RIGHT SIDE
            (FT)           (FT)
=-100.,100
```

(The screen is erased and Figures 13 and 14 are displayed. Since the input graphic redisplay for other methods of analysis is not desired, the input interactive sequence is exited.)

```
    DO YOU WANT TO REPLOT WITH NEW DISTANCES FROM WALL?
    ENTER 'YES' OR 'NO'
=NO
    DO YOU WANT GEOMETRY PLOTTED FOR ANOTHER METHOD?
    ENTER 'YES' OR 'NO'
=NO
```

19. If the user responds with GEOMETRY to the question in paragraph 12, only the input geometry redisplay will be executed. Control is then transferred to the main program for continued execution.

PROBLEM - ANCH1 - ANCHORED WALL DESIGN - GRANULAR SOIL
FROM 'FOUNDATION ANALYSIS AND DESIGN' BY J. E. BOWLES
EXAMPLE 13-3, PP 429-431

LEFTSIDE SOIL PROPERTIES

LAYER	C	PHI	GAMMA	DELTA
L1	0.	30.0	128.5	20.0

RIGHTSIDE SOIL PROPERTIES

LAYER	C	PHI	GAMMA	DELTA
R1	0.	30.0	105.0	20.0
R2	0.	30.0	128.5	20.0

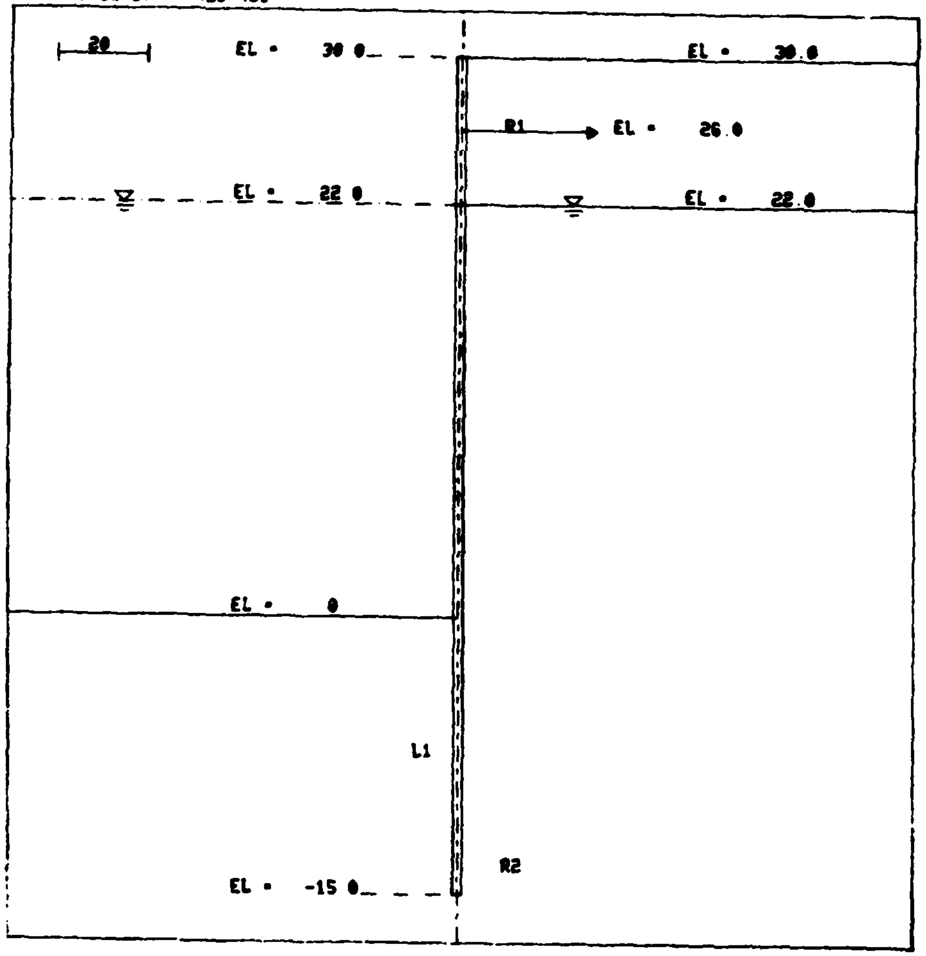


Figure 13. Input geometry redisplay for problem "ANCH1" (fixed earth method of analysis)

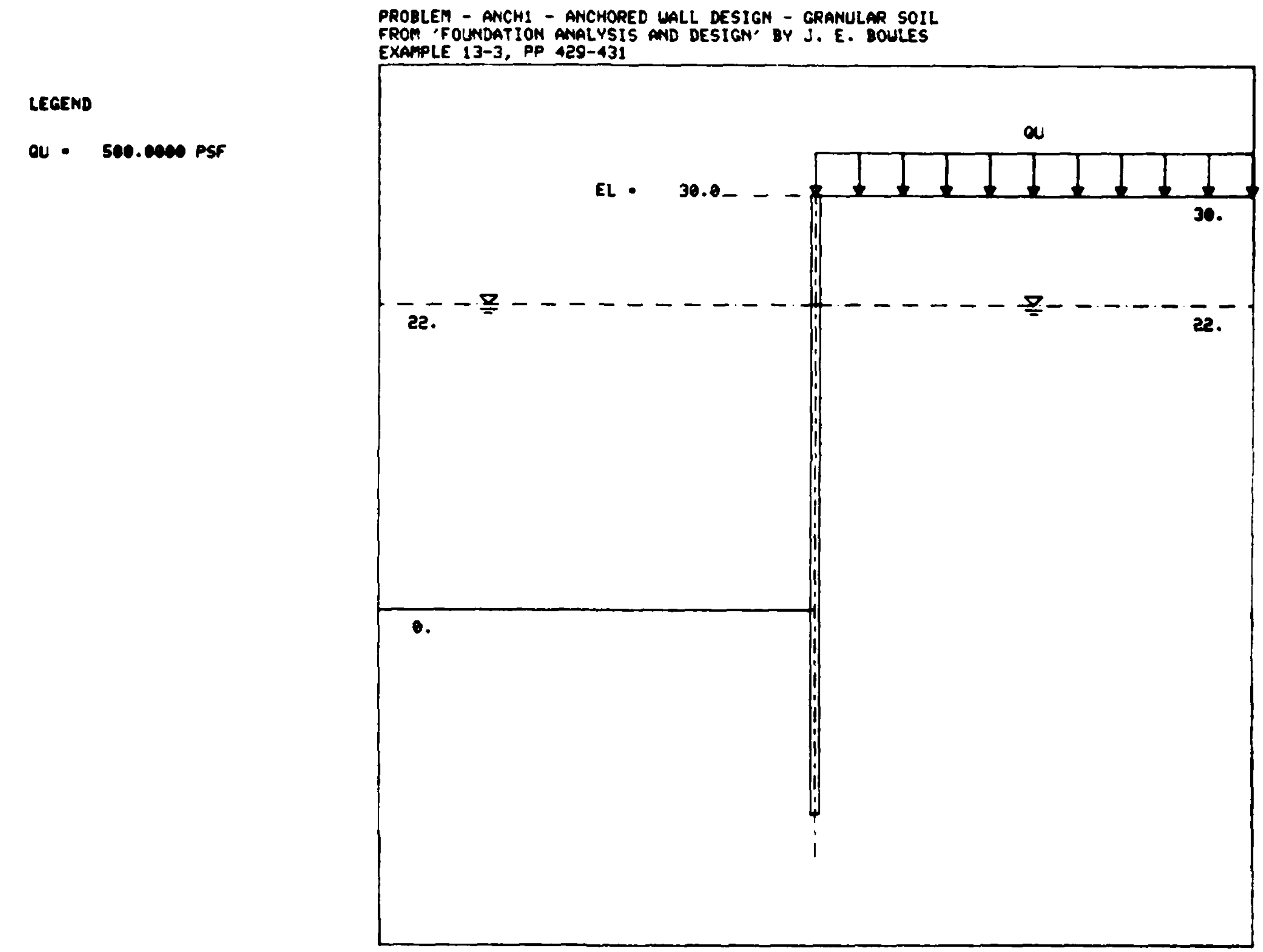


Figure 14. Input geometry applied loads redisplay for problem "ANCH1" (fixed earth method of analysis)

20. A response of BOTH to the question in paragraph 12 will execute the input geometry redisplay as discussed earlier and then direct the display of shear, moment, deflection, and pressure plots for the methods of computation available. A response of RESULTS to the question will execute only the plotting of the shear, moment, deflection, and pressure diagrams. It should again be pointed out that, for cantilevered wall design, the method of solution option is not requested by the program.

21. For anchored wall designs, the following is output:

```
*** O U T P U T   S E L E C T E D ***
```

Then, the question in paragraph 13 is again asked to determine the method of analysis for which to make the shear, moment, deflection, or pressure plots. The user then has the option to select the plot to be displayed:

```
    ENTER NUMBER CODE FOR RESULTS TO BE PLOTTED
         1=BENDING MOMENT
         2=SHEAR
         3=SCALED DEFLECTION
         4=NET PRESSURE
=
```

If he incorrectly responds to the above question, it is repeated.

22. Once a correct response is given, the minimum and maximum computed values of the desired plot parameter are printed. The user must then enter a minimum and a maximum value to set up his display limits. The minimum value must be less than the minimum computed value printed. The maximum value must be greater than the maximum computed value printed. For example, if the user selects the bending moment to be plotted, the following illustrates this feature:

```
    MIMIMUM AND MAXIMUM BENDING MOMENT RESULTS
         MINIMUM =     -1522.
         MAXIMUM =     76537.
    ENTER MINIMUM AND MAXIMUM LIMITS FOR AXES.
    MUST BE LESS THAN MINIMUM AND GREATER THAN
    MAXIMUM RESULTS, RESPECTIVELY
         MINIMUM     MAXIMUM
=-85ØØØ.,85ØØØ.
```

For symmetric plots, the user should input the minimum equal to the negative of the ximum. Nonsymmetric plots may be made, but care should be taken that some of the graphics output not be "clipped."

23. The user must next enter a desired interval value for labelling the horizontal axes (always positive):

```
    ENTER INTERVAL FOR LABELLING VALUES ON AXES
=
```

The screen is then erased and the plot displayed. Upon completion of the plot, a bell rings and execution is temporarily suspended to allow the user to make a hardcopy. To resume execution, he simply enters a carriage return.

24. The user is next given the opportunity to replot with new minimum and maximum limits (different scale):

```
    DO YOU WANT TO REPLOT RESULTS WITH NEW
    MINIMUM AND MAXIMUM LIMITS FOR PLOT AXES?
    ENTER 'YES' OR 'NO'
=
```

A YES response returns the user to the number code selection question in paragraph 21.

25. A NO response gives the user the opportunity to select another plot from the same method of analysis:

```
    DO YOU WANT OTHER RESULTS PLOTTED?
    FOR THE SAME METHOD
    ENTER 'YES' OR 'NO'
=
```

A response of YES returns the user again to the number code selection question in paragraph 21.

26. If the user responds with NO, he has the opportunity to select another method to be plotted:

```
    DO YOU WANT PLOTS FOR ANOTHER METHOD?
    ENTER 'YES' OR 'NO'
=
```

A response of YES returns him to the method of selection question in paragraph 13. A NO response exits the output graphics portion of the code.

27. The following is an example (again for problem "ANCH1") of the output options for one available method:

```
*** O U T P U T   S E L E C T E D ***
    RESULTS ARE AVAILABLE FOR FOLLOWING METHOD OF ANALYSIS
         FREE EARTH : ENTER 'FR' ON CUE
         FIXED EARTH: ENTER 'FI' ON CUE
         EQUIV BEAM : ENTER 'EB' ON CUE
         EQUAL MOM  : ENTER 'EM' ON CUE
         TERZAGHI   : ENTER 'TE' ON CUE
    ENTER METHOD FOR WHICH RESULTS ARE TO BE PLOTTED
=FR
```

(The free earth method of analysis is selected. The screen is erased.)

```
    ENTER NUMBER CODE FOR RESULTS TO BE PLOTTED
         1=BENDING MOMENT
         2=SHEAR
         3=SCALED DEFLECTION
         4=NET PRESSURE
=1
    MINIMUM AND MAXIMUM BENDING MOMENT RESULTS
         MINIMUM =     -1522.
         MAXIMUM =     76537.
    ENTER MINIMUM AND MAXIMUM LIMITS FOR AXES.
    MUST BE LESS THAN MINIMUM AND GREATER THAN
    MAXIMUM RESULTS, RESPECTIVELY
         MINIMUM    MAXIMUM
=-85ØØØ.,85ØØØ.
    ENTER INTERVAL FOR LABELLING VALUES ON AXES
=2ØØØØ.
```

(The bending moment plot is selected. A symmetric plot is desired and a tic interval of 20,000 lb-ft is entered. The screen is erased and a bending moment diagram is plotted as shown in Figure 15. A bell rings and execution is temporarily halted for the user to make a hardcopy, if desired. If he enters a carriage return, the screen is erased and another plot is selected for the same method.)

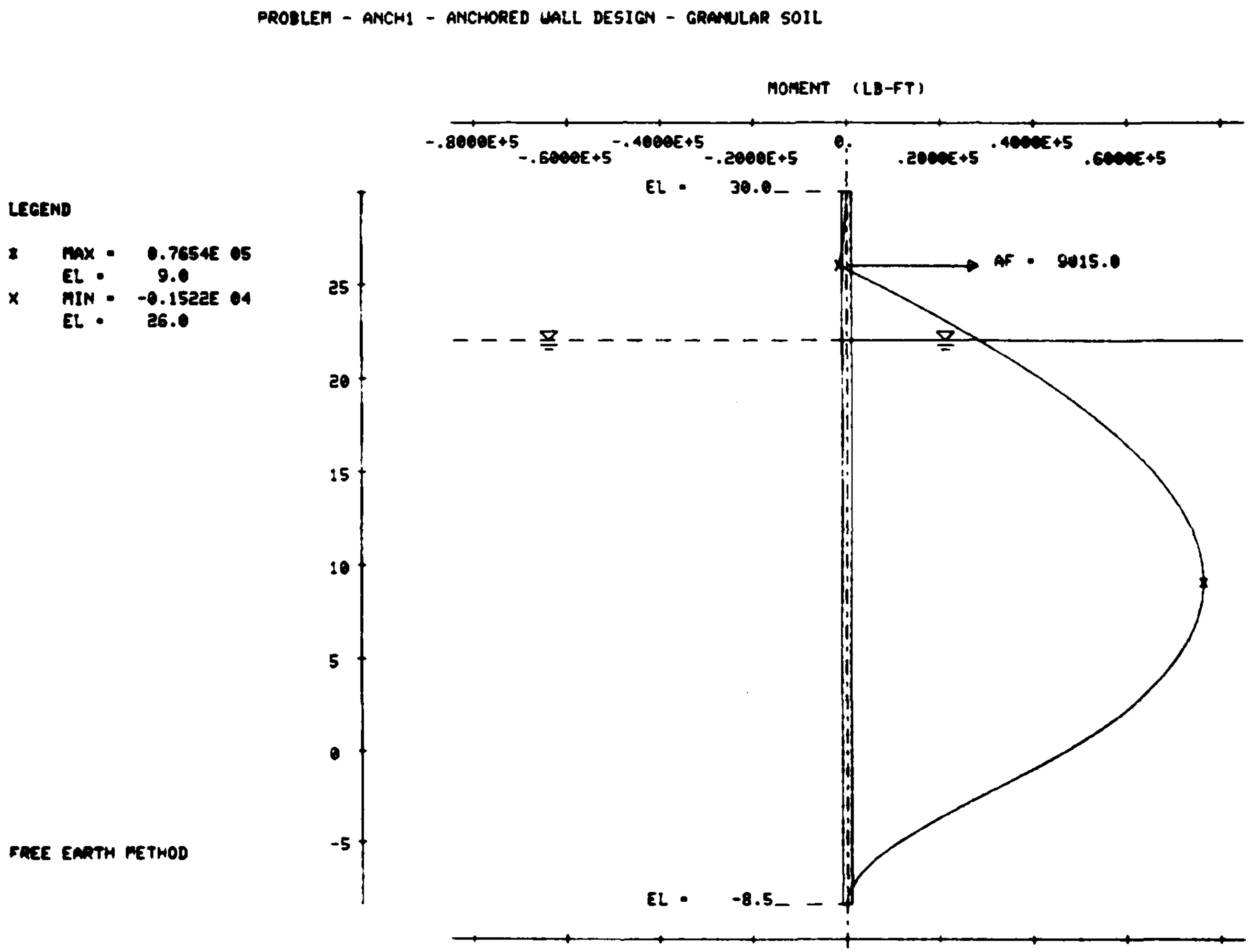


Figure 15. Output bending moment results for problem "ANCH1" (free earth method of analysis)

```
    DO YOU WANT TO REPLOT RESULTS WITH NEW
    MINIMUM AND MAXIMUM LIMITS FOR PLOT AXES?
    ENTER 'YES' OR 'NO'
=NO
    DO YOU WANT OTHER RESULTS PLOTTED?
    FOR THE SAME METHOD
    ENTER 'YES' OR 'NO'
=YES
```

(The screen is erased.)

```
    ENTER NUMBER CODE FOR RESULTS TO BE PLOTTED
         1=BENDING MOMENT
         2=SHEAR
         3= SCALED DEFLECTION
         4=NET PRESSURE
=2
    MINIMUM AND MAXIMUM SHEAR RESULTS ARE
         MINIMUM =      -7586.
         MAXIMUM =       8171.
    ENTER MINIMUM AND MAXIMUM LIMITS FOR AXES.
    MUST BE LESS THAN MINIMUM AND GREATER THAN
    MAXIMUM RESULTS, RESPECTIVELY
         MINIMUM     MAXIMUM
=-10000.,10000.
    ENTER INTERVAL FOR LABELLING VALUES ON AXES
=5000.
```

(The shear plot is selected. The appropriate display limits and tic interval are entered. The screen is erased and a shear diagram is made as shown in Figure 16. A bell again rings and execution is temporarily halted to make a hardcopy. After the user enters a carriage return, the screen is erased and another plot is selected for the same method.)

```
    DO YOU WANT TO REPLOT RESULTS WITH NEW
    MINIMUM AND MAXIMUM LIMITS FOR PLOT AXES?
    ENTER 'YES' OR 'NO'
=NO
    DO YOU WANT OTHER RESULTS PLOTTED?
    FOR THE SAME METHOD
    ENTER 'YES' OR 'NO'
=YES
```

(The screen is erased.)

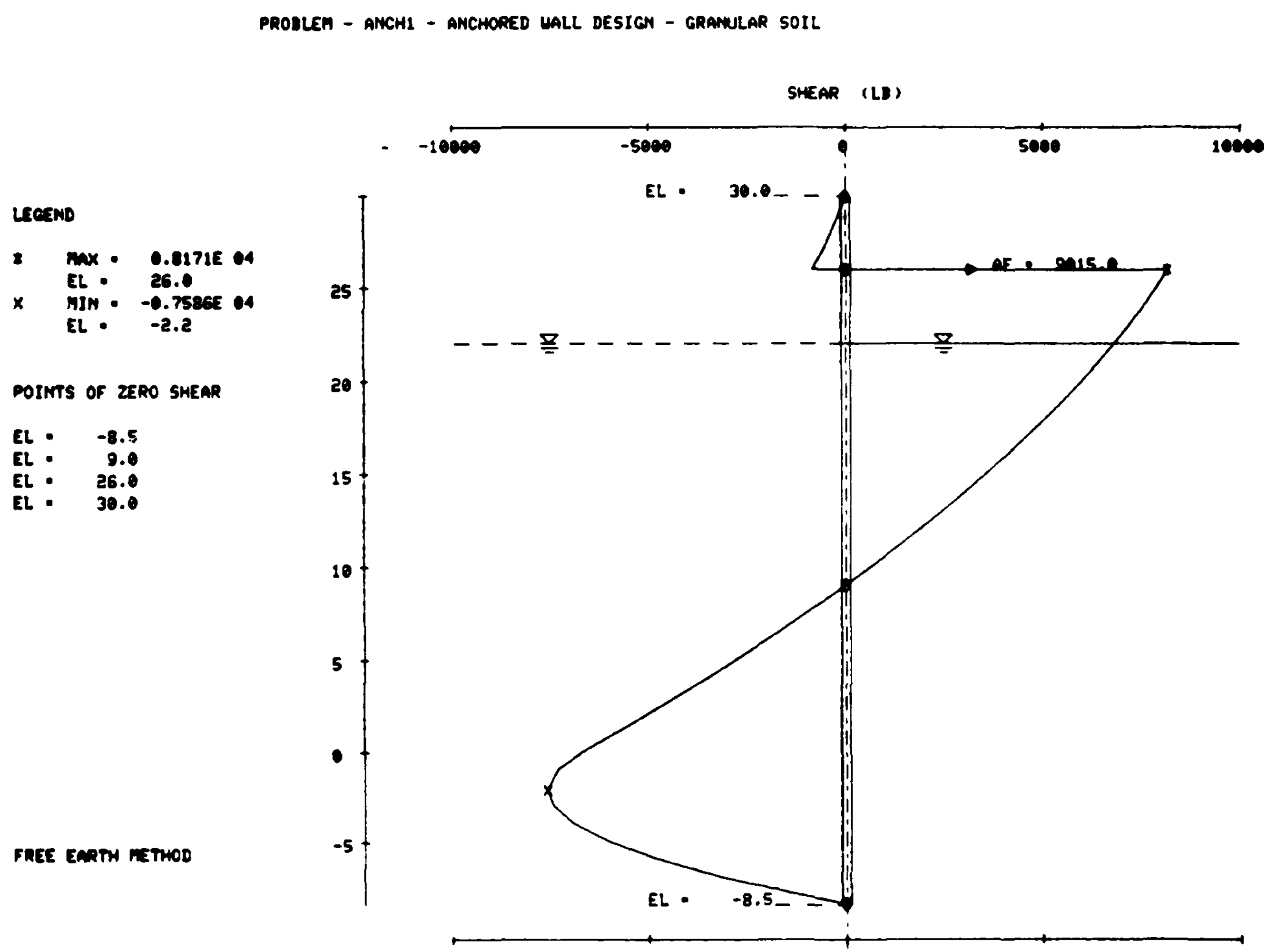


Figure 16. Output shear force results for problem "ANCH1" (free earth method of analysis)

```
    ENTER NUMBER CODE FOR RESULTS TO BE PLOTTED
         1=BENDING MOMENT
         2=SHEAR
         3=SCALED DEFLECTION
         4=NET PRESSURE
=3
    MINIMUM AND MAXIMUM SCALED DEFLECTIONS ARE
         MINIMUM =  -5.76E Ø9
         MAXIMUM =   1.56E 1Ø
    ENTER MINIMUM AND MAXIMUM LIMITS FOR AXES.
         MINIMUM     MAXIMUM
=-2.5E+1Ø 2.5E+1Ø
    ENTER INTERVAL FOR LABELLING VALUES ON AXES
=1.ØE+1Ø
```

(The scaled deflection plot is selected. the appropriate display limits and tic interval are entered. The screen is erased and scaled deflection is displayed as shown in Figure 17. Execution is again halted for hardcopy purposes. Once the user enters a carriage return, the screen is erased and the option to replot is taken.)

```
    DO YOU WANT TO REPLOT RESULTS WITH NEW
    MINIMUM AND MAXIMUM LIMITS FOR PLOT AXES?
    ENTER 'YES' OR 'NO'
=YES
```

(The screen is erased.)

```
    ENTER NUMBER CODE FOR RESULTS TO BE PLOTTED
         1=BENDING MOMENT
         2=SHEAR
         3=SCALED DEFLECTION
         4=NET PRESSURE
=3
    MINIMUM AND MAXIMUM SCALED DEFLECTIONS ARE
         MINIMUM =  -5.76E Ø9
         MAXIMUM =   1.56E 1Ø
    ENTER MINIMUM AND MAXIMUM LIMITS FOR AXES.
         MINIMUM     MAXIMUM
=-5.ØE+1Ø 1Ø.E+1Ø
    ENTER INTERVAL FOR LABELLING VALUES ON AXES
=4.ØE+1Ø
```

(The scaled deflection plot is again selected. New display limits and tic interval are entered (nonsymmetric).

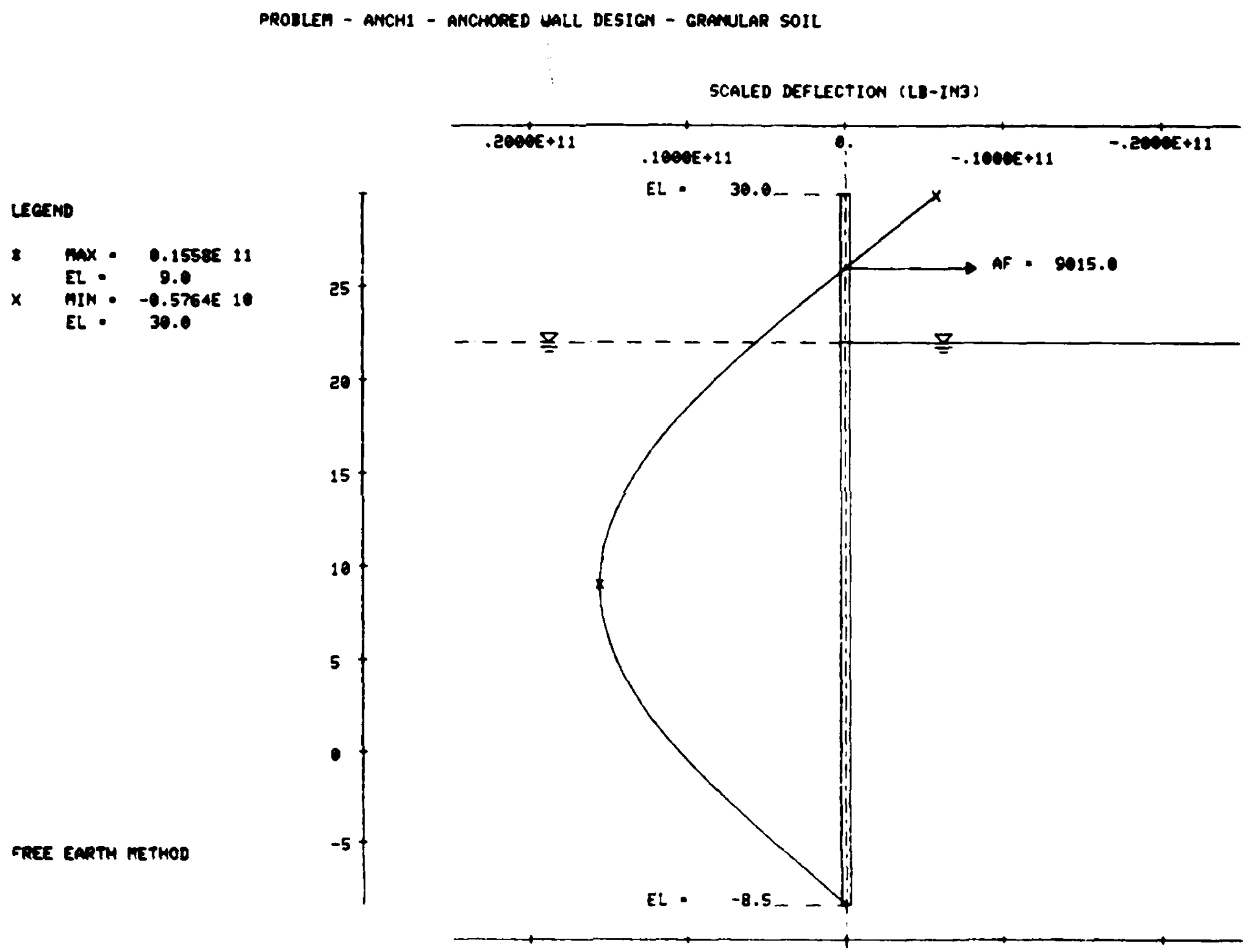


Figure 17. Output of scaled deflection for problem "ANCH1" (free earth method of analysis)

The screen is erased and scaled deflection is replotted as shown in Figure 18. Again, a hardcopy can be taken if desired. After a carriage return is entered, the screen is erased and another plot is selected for the same method of analysis.)

```
    DO YOU WANT TO REPLOT RESULTS WITH NEW
    MINIMUM AND MAXIMUM LIMITS FOR PLOT AXES?
    ENTER 'YES' OR 'NO'
=NO
    DO YOU WANT OTHER RESULTS PLOTTED?
    FOR THE SAME METHOD
    ENTER 'YES' OR 'NO'
=YES
```

(The screen is erased.)

```
    ENTER NUMBER CODE FOR RESULTS TO BE PLOTTED
         1=BENDING MOMENT
         2=SHEAR
         3=SCALED DEFLECTION
         4=NET PRESSURE
=4
    MINIMUM AND MAXIMUM NET PRESSURE RESULTS ARE
         MINIMUM =   -2411.54
         MAXIMUM =     83Ø.1Ø
    ENTER MINIMUM AND MAXIMUM LIMITS FOR AXES.
    MUST BE LESS THAN MINIMUM AND GREATER THAN
    MAXIMUM RESULTS, RESPECTIVELY
         MINIMUM     MAXIMUM
=-35ØØ.,35ØØ.
    ENTER INTERVAL FOR LABELLING VALUES ON AXES
=1ØØØ.
```

(The net pressure plot is selected. The appropriate display limits and tic interval are entered. The screen is erased and a net pressure diagram is displayed as shown in Figure 19. A hardcopy can again be taken if desired. After the user enters a carriage return, the screen is erased and the output graphics sequence is exited.

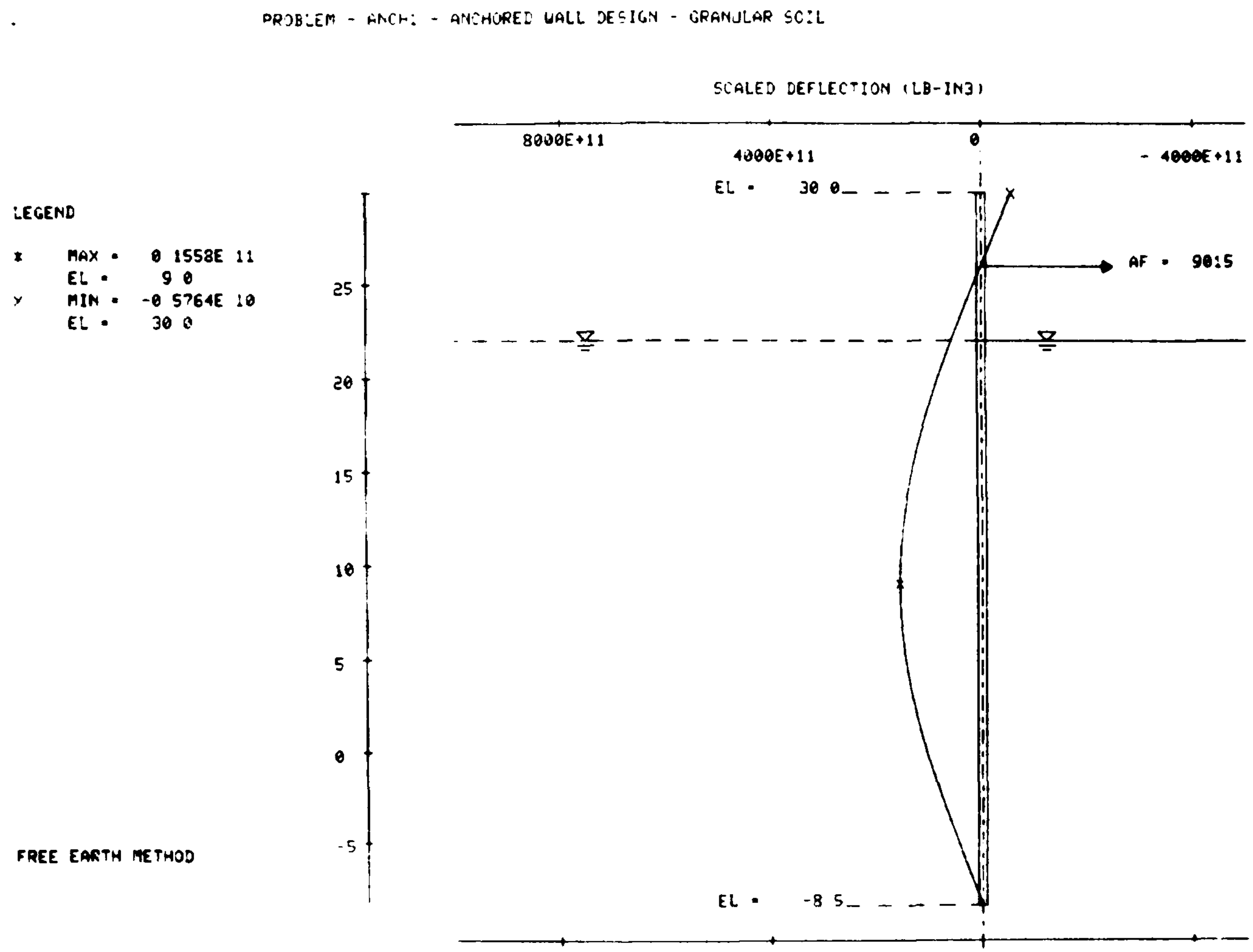


Figure 18. Replot of scaled deflection for problem "ANCH1" (free earth method of analysis)

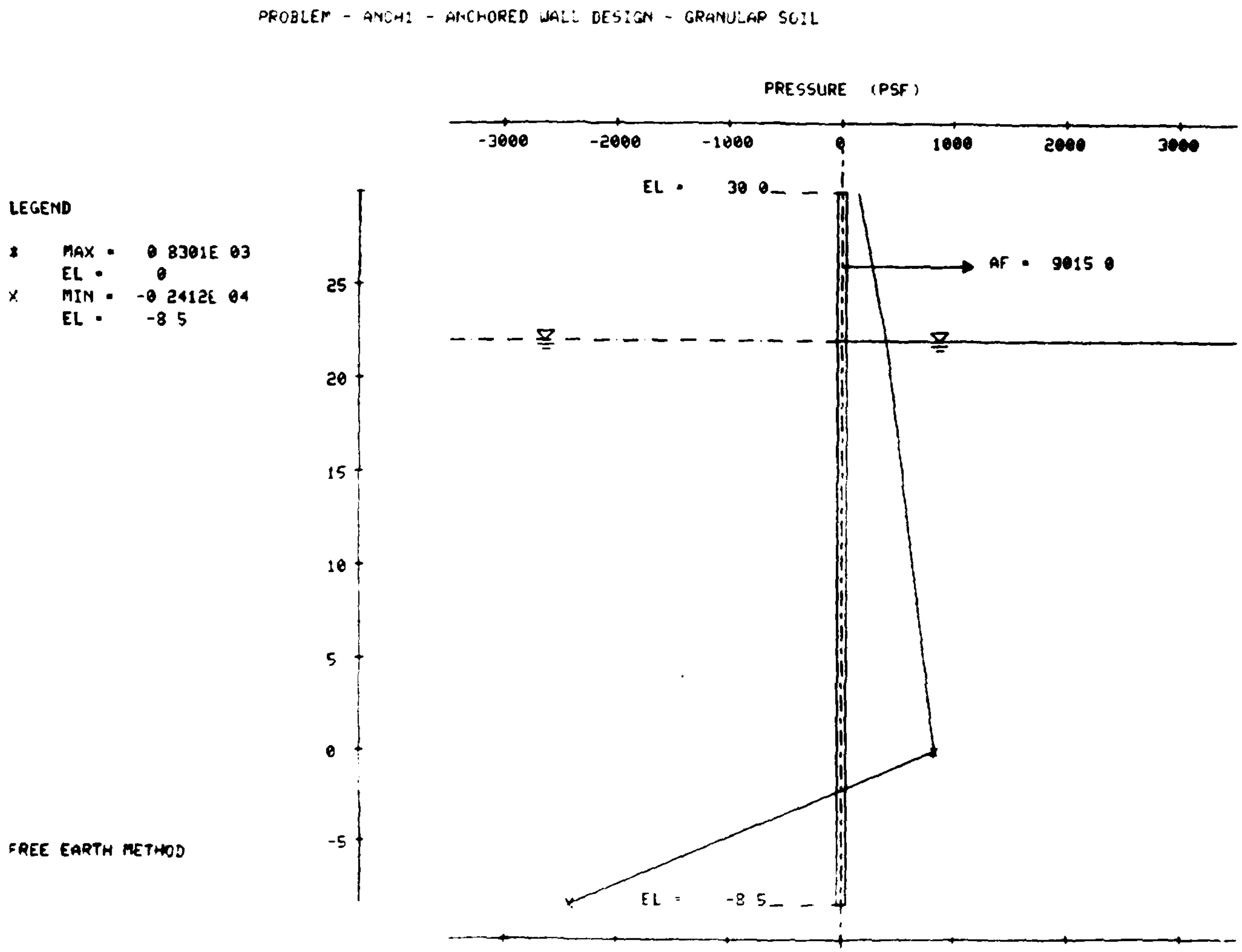


Figure 19. Output of net pressure for problem "ANCH1"
(free earth method analysis)

```
    DO YOU WANT TO REPLOT RESULTS WITH NEW
    MINIMUM AND MAXIMUM LIMITS FOR PLOT AXES?
    ENTER 'YES' OR 'NO'
=NO
    DO YOU WANT OTHER RESULTS PLOTTED?
    FOR THE SAME METHOD
    ENTER 'YES' OR 'NO'
=NO
    DO YOU WANT PLOTS FOR ANOTHER METHOD?
    ENTER 'YES' OR 'NO'
=NO
```

(The user is then returned to the main problem for continued execution.)

Appendix A: Input Data Guide

Notes and General Requirements

for Wall Description

1. Coordinate System

   a. The wall is assumed to be vertical.

   b. All elevations and distances are assumed to be given in feet.

   c. All vertical dimensions are given as elevations with respect to an arbitrary datum. Elevations increase toward the top of the wall.

   d. All horizontal dimensions are given as the positive distance in feet from the wall, increasing away from the wall. There are no negative horizontal distances.

   e. Impending rotation of the wall is assumed to be counterclockwise for cantilever walls and clockwise for anchored walls.

2. Top of Wall

   a. The elevation of the top of the wall must be at or above the intersection of the rightside surface with the wall (i.e., TOPEL $\geq$ SURELR(1), Figure A2).

3. Anchor

   a. For an anchored wall, a horizontal anchor is assumed.

   b. The anchor must be at or below the elevation of the top of the wall (i.e., ANCHEL $\leq$ TOPEL, Figure A1).

4. Bottom of Wall

   a. The elevation of the bottom of the wall, BOTEL (Figure A1) is determined in the "Design" mode.

   b. The elevation of the bottom of the wall, BOTEL (Figure A1) must be provided in the "Analysis" mode.

5. Rightside Soil Surface (Figure A2)

   a. The general rightside surface is assumed to be described by pairs of coordinates giving the elevation and distance from the wall for up to fifteen (15) points on the surface. The surface between adjacent points is assumed to be a straight line.

      a(1) The first point is at the intersection of the surface and the wall. The elevation of the first point must be at or below the top of the wall.

      a(2) If only one (1) surface point is provided, a horizontal rightside surface is assumed.

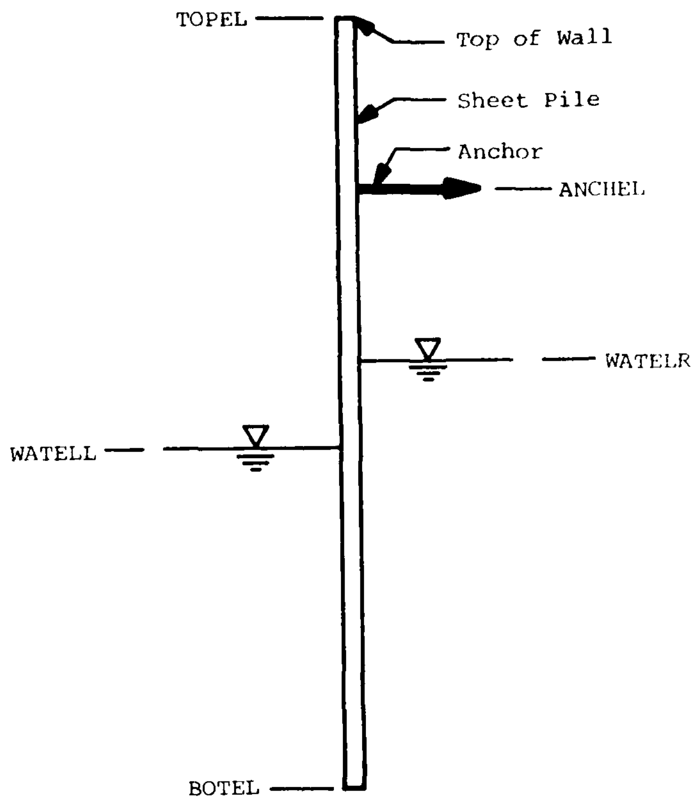
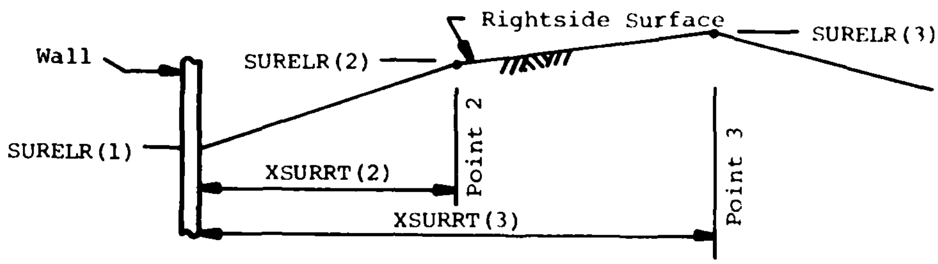
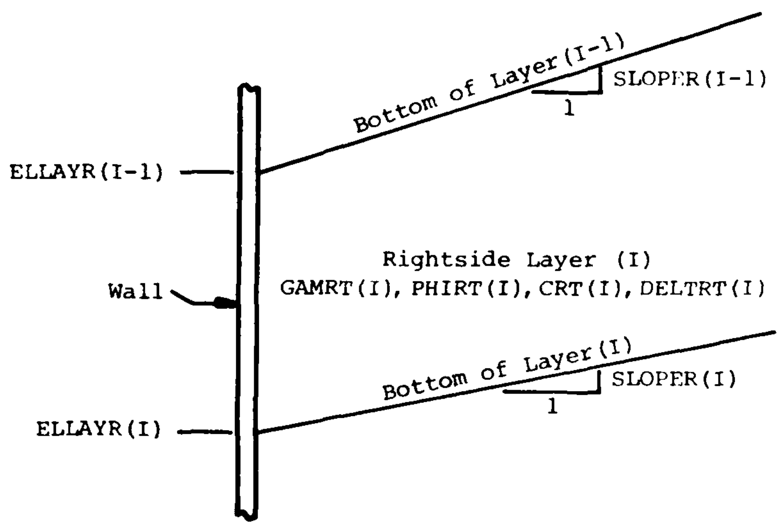


Figure A1. Data names for wall, water, and anchor elevations and horizontal line loads



(a) Rightside Surface Coordinates



(b) Rightside Layer Data

Figure A2. Data names for rightside soil a(3) The rightside surface is assumed to extend horizontally ad infinitum beyond the last surface point provided.

a(4) The slope of every segment of the surface must be less than or equal to the effective angle of internal friction for the top rightside soil layer.

7. Rightside Soil Layers (see Figure A2)

a. The soil on the rightside of the wall is assumed to be composed of one (1) to fifteen (15) soil layers. Soil properties as follow are assumed to be constant within each layer.

a(1) Unit weight, GAMRT, (PCF) input is assumed to be for unsubmerged soil. Submerged unit weight is determined from the position of the water surface on the rightside.

a(2) Angle of internal friction, PHIRT, (DEG) must be greater than or zero if CRT (see next paragraph) is equal to zero.

a(3) Cohesion, CRT, (PSF) must be greater than zero if PHIRT is equal to zero.

a(4) Angle of wall friction, DELTRT, (DEG).

b. Adjacent soil layers are assumed to be separated by a straight line which extends ad infinitum from the wall. The boundary between layers is associated with the layer above and is described by

b(1) The elevation, ELLAYR, at which the boundary intersects the wall.

b(2) The slope, SLOPER, of the wall expressed in feet of rise per foot. A positive slope extends up away from the wall.

b(3) Layer boundary lines may not intersect (i.e., must be parallel or diverge away from the wall).

c. The last soil layer provided is assumed to extend ad infinitum downward.

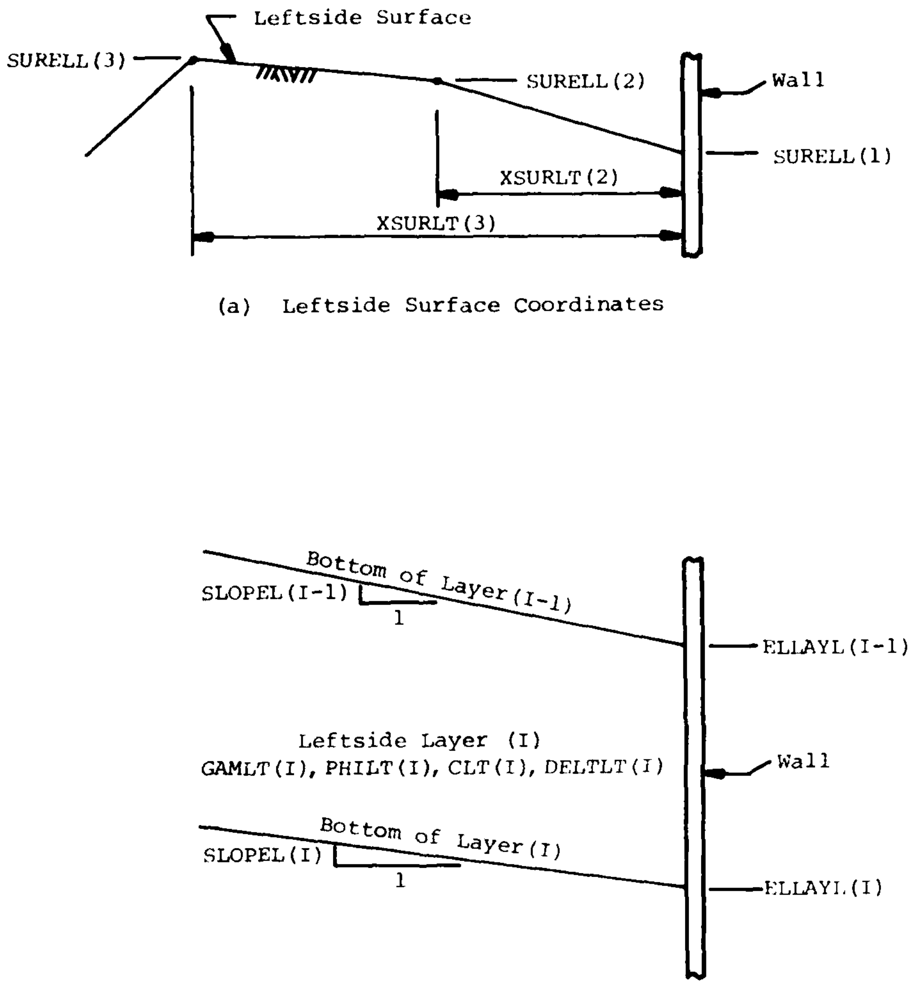
8. Leftside Soil Surface (see Figure A3)

a. The general leftside surface is assumed to be described by pairs of coordinates giving the elevation and distance from the wall for up to fifteen (15) points on the surface. The surface between adjacent points is assumed to be a straight line.

a(1) The first point is at the intersection of the surface and the wall and must be at or below the top of the wall.

a(2) If only one (1) surface point is provided, a horizontal surface is assumed.

a(3) The leftside surface is assumed to extend horizontally ad infinitum beyond the last surface point provided.



(a) Leftside Surface Coordinates

(b) Leftside Layer Data

Figure A3. Data names for leftside soil

a(4) The slope of every segment of the leftside surface must be less than or equal to the effective angle of internal friction for the top leftside soil layer.

9. Leftside Soil Layers (see Figure A3)

a. The soil on the leftside of the wall is assumed to be composed of one (1) to fifteen (15) soil layers. Soil properties as follow are assumed to be constant within each layer.

a(1) Unit weight, GAMLT, (PCF) is assumed to be for unsubmerged soil. Submerged unit weight will be determined from the position of the leftside water surface.

a(2) Angle of internal friction, PHILT, (DEG) must be greater than zero if CLT (see next paragraph) is equal to zero.

a(3) Cohesion, CLT, (PSF) must be greater than zero if PHILT is equal to zero.

a(4) Angle of wall friction, DELTLT, (DEG).

10. Water Data

a. When seepage effects are not included, water on either side of the wall may be at any elevation.

b. When seepage effects are included, the following must be observed.

b(1) Water elevation on right side must be above water elevation on left side.

b(2) Seepage is assumed to commence on the right side at the lower of WATELR and SURELR(1).

b(3) Seepage is assumed to cease on the left side at the lower of WATELL and SURELL(1).

b(4) The value of seepage gradient provided as input must be positive, less than one; and must not result in zero net water pressure above the point at which seepage ceases on the left side.

11. Vertical Surcharge Loads on Rightside Surface (see Figure A4)

a. Load units are assumed to be pounds per lineal foot (PLF) for line loads and pounds per square foot (PSF) for distributed loads.

b. Zero (0) to four (4) line loads may be applied at any point on the rightside surface.

c. Zero (0) or one (1) distributed surcharge load may be applied as shown in Figures A4b, A4c, A4d, and A4e.

c(1) A uniform distributed load (Figure A4b) may only be applied to a horizontal surface.

c(2) Distributed strip and triangular loads must be applied to a horizontal segment of the rightside surface.

c(3) A ramp load may be applied only on a horizontal surface or on the extension of a final horizontal segment of an irregular surface.

c(4) A rightside surface point may not lie within the limits of a distributed load.

12. Horizontal Line Loads (see Figure A5a)

a. Load units are assumed to be pounds per lineal foot (PLF).

b. Zero (0) to four (4) horizontal line loads may be applied anywhere at or below the top of the wall.

c. Positive horizontal loads act to the left.

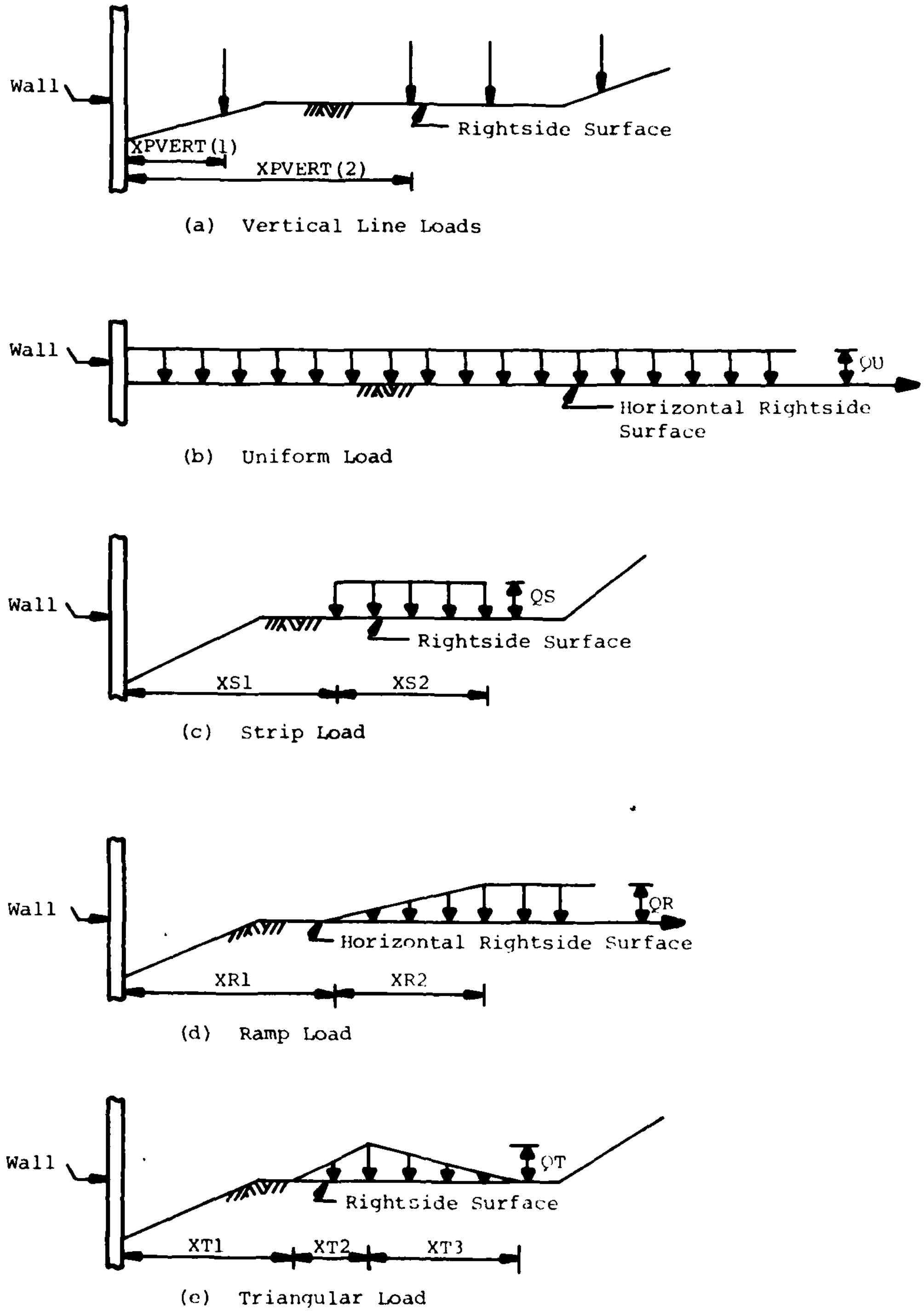
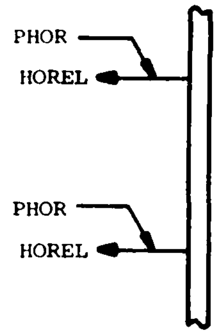
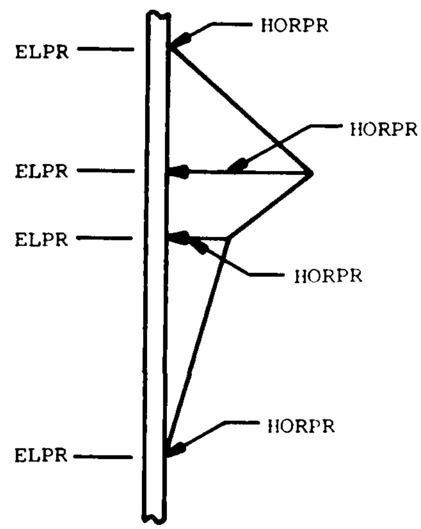


Figure A4. Data names for surcharge loads



(a) Horizontal Line Loads



(b) Horizontal Distributed Load

Figure A5. Horizontal applied loads

13. Horizontal Applied Pressure Distribution (see Figure A5b)

   a. A general applied pressure distribution is assumed to be described by pairs of values giving the elevation and magnitude of pressure for up to twelve points. The distribution is assumed to be linear between adjacent points.

b. Points must be supplied in sequential order with elevations progressing downward.

c. Dual pressure values at a single elevation are not permitted.

d. The elevation of the first point must be at or below the top of the wall.

e. All pressure values must have the same sign (either positive or negative).

f. At least two points are required to describe a distribution.

g. Pressure units are assumed to be pounds per square foot (PSF).

14. Input Data

a. Input data may be entered during execution from the user's terminal or may be stored in a permanent file before the program is executed. The file name must be one (1) to six (6) alphanumeric characters beginning with an alphabetic character.

b. Data are read in free field format.

b(1) Data items on lines designated (alphanumeric) must be separated by one or more blanks.

b(2) Data items on lines designated (numeric) may be separated by commas.

b(3) Integer number values must be of form NNNN.

b(4) Real number values may be of form XXXX, XX.XX, X.XXE+ee.

c. Each line in a data file must begin with a nonzero integer line number denoted LN below. Line numbers are not required when data are entered during execution from the user's terminal.

d. Input data lines must be in the sequence described below. Line descriptors enclosed in brackets [ ] or braces { } may not be required.

e. Lower case words enclosed by single quotes, in the description below indicate alphanumeric information.

f. All alphanumeric keywords may be abbreviated with the underlined character(s).

15. Input Data Sequence and Description

a. Header--One (1) to four (4) lines are provided for identifying the run.

a(1) Header Line 1 (alphanumeric)

(a) Contents

[LN] NLINES 'heading'

(b) Definitions

[LN] = line number (not required if data entered during execution from user's terminal)

NLINES = total number of header lines = integer 1 to 4

'header' = any alphanumeric information

(c) Total characters on Header Line 1 including LN, NLINES, 'heading,' and embedded blanks must be ≤ 80. Blank 'heading' is not permitted.

a(2) Header Lines 2 to NLINES ([data] not required if NLINES = 1) (alphanumeric)

(a) Contents

[LN]['heading']

(b) Total characters including LN, 'heading,' and embedded blanks must be ≤ 80. Blank 'heading' is not permitted.

b. Wall Type, Mode, Method--One (1) Line (alphanumeric)

b(1) Contents

[LN] 'type' 'mode' [nmethods] ['methods']

b(2) Definitions

'type' = CANTILEVER or ANCHORED

'mode' = ANALYSIS or DESIGN

[nmethods] (not required if 'type' = CANTILEVER)
= integer 1 to 5 indicating the number of methods described below to be used in ANALYSIS or DESIGN of an anchored wall

['methods'] (not required if 'type' = CANTILEVER)
1 to 5 of the following codes

= FR for Free Earth Method

= FI for Fixed Earth Method

= EB for Equivalent Beam Method

= EM for Equal Moment Method

= TE for Terzaghi Method

c. Wall Description--One (1) Line (numeric)

c(1) Contents if 'type' = CANTILEVER and 'mode' = DESIGN

[LN] TOPEL FS

c(2) Contents if 'type' = CANTILEVER and 'mode' = ANALYSIS

[LN] TOPEL BOTEL EMOD SECMOM

c(3) Contents if 'type' = ANCHORED and 'mode' = DESIGN

[LN] TOPEL ANCHEL FS

c(4) Contents if 'type' = ANCHORED and 'mode' = ANALYSIS

[LN] TOPEL ANCHEL BOTEL EMOD SECMOM

c(5) Definitions

TOPEL = elevation of top of wall (FT)

ANCHEL = elevation of anchor (FT)

BOTEL = elevation of bottom of wall (FT)

FS = factor of safety

EMOD = modulus of elasticity (PSI)

SECMOM = moment of inertia (IN^4)

d. Rightside Soil Description--Three (3) to twenty-two (22) lines

d(1) Control--One (1) line (numeric)

(a) Contents

[LN] NSURRT NLAYRT

(b) Definitions

NSURRT = number of rightside surface points (1 to 15)

NLAYRT = number of rightside soil layers (1 to 15)

d(2) Rightside Surface Point Coordinates--({data} not required if NSURRT = 1) (numeric)

(a) Surface Point Elevations, NSURRT Values, five (5) per line

[LN] SURELR(1) {SURELR(2)...SURELR(NSURRT)}

(b) Surface Point X-Coordinates, NSURRT-1 Values, five (5) per line, omit entire line if NSURRT = 1

[LN] {XSURRT(2)...XSURRT(NSURRT)}

(c) Definitions

SURELR(I) = elevation of Ith surface point (FT)

XSURRT(I) = distance from wall to Ith surface point (FT)

Point numbers start with 1 at wall and proceed in sequence away from wall

d(3) Rightside Soil Layer Data--NLAYRT lines (numeric) ({data} not required for I = NLAYRT) (Layer 1 is surface layer, layers proceed sequentially downward)

(a) Contents

[LN] GAMRT(I) PHIRT(I) CRT(I) DELTRT(I) {ELLAYR(I), SLOPER(I)}

(b) Definitions

GAMRT(I) = unsubmerged unit weight (PCF)

PHIRT(I) = angle of internal friction (DEG)

CRT(I) = cohesion (PSF)

DELTRT(I) = angle of wall friction (DEG)

ELLAYR(I) = elevation at wall of boundary between layer I and layer I + 1 (FT)

SLOPER(I) = slope of boundary between layer I and layer I + 1 (FT) (interpreted as rise per foot, positive if boundary slopes up away from wall)

e. Leftside Soil Description--Three (3) to twenty-two (22) lines

e(1) Control--One (1) line (numeric)

(a) Contents

[LN] NSURLT NLAYLT

(b) Definitions

NSURLT = number of leftside surface points (1 to 15)

NLAYLT = number of leftside soil layers (1 to 15)

e(2) Leftside Surface Point Coordinates--({data} not required if NSURLT = 1) (numeric)

(a) Surface Point Elevations, NSURLT Values, five (5) per line

[LN] SURELL(1) {SURELL(2)...SURELL(NSURLT)}

(b) Surface Point X-Coordinates, NSURLT-1 Values, five (5) per line, omit entire line if NSURLT = 1

[LN] {XSURLT(2)...XSURLT(NSURLT)}

(c) Definitions

SURELL(I) = elevation of Ith surface point (FT)

XSURLT(I) = distance from wall to Ith surface (FT)

Point numbers start with 1 at wall and proceed in sequence away from wall

e(3) Leftside Soil Layer Data--NLAYLT lines ({data} not required for I = NLAYLT)

(a) Contents

[LN] GAMLT(I) PHILT(I) CLT(I) DELTLT(I) {ELLAYL(I), SLOPEL(I)}

(b) Definitions

GAMLT(I) = unsubmerged unit weight (PCF)

PHILT(I) = angle of internal friction (DEG)

CLT(I) = cohesion (PSF)

DELTLT(I) = angle of wall friction (DEG)

ELLAYL(I) = elevation at wall of boundary between layer I and layer I + 1 (FT)

SLOPEL(I) = slope of boundary between layer I and layer I + 1 (FT) (interpreted as rise per foot, positive if boundary slopes up away from wall)

f. Water Data--One (1) line (numeric)

f(1) Contents

[LN] WATELR WATELL GAMWAT SEEP

f(2) Definitions

WATELR = water elevation on rightside (FT)

WATELL = water elevation on left side (FT)

GAMWAT = unit weight of water (PCF) (If GAMWAT input as zero, default to GAMWAT = 62.4. If GAMWAT input as negative, water effects are not considered)

SEEP = seepage gradient FT/FT)

g. Vertical Loads on Rightside--One (1) to three (3) lines (alphanumeric)

g(1) Control--One (1) line

(a) Contents

[LN] NPVERT 'distributed load'

(b) Definitions

NPVERT = number of vertical concentrated loads (0 to 4)

'distributed load' = NONE if no distributed load
= UNIFORM for uniform load
= STRIP for strip load
= RAMP for ramp load
= TRIANGULAR for triangular load

g(2) Vertical Line Loads--Zero (0) or one (1) line ([data] not required if NPVERT = 0)

(a) Contents

[LN] [XPVERT(I) PVERT(I)...XPVERT(NPVERT) PVERT(NPVERT)]

(b) Definitions

XPVERT(I) = distance of Ith load from wall (FT)

PVERT(I) = magnitude of Ith load (PLF)

g(3) Distributed Vertical Load--Zero (0) or one (1) line (numeric)
([data] not required if 'distributed load' = NONE)
({data} not required if 'distributed load' ≠ TRIANGULAR)

(a) Contents

[LN] [X1 X2 {X3} Q]

(b) Definitions

X1 = distance from wall to start of STRIP, RAMP, or TRIANGULAR load (FT)

X2 = width of STRIP distribution (FT)
= width of increasing load for RAMP or TRIANGULAR (FT)

X3 = width of decreasing load for TRIANGULAR (FT)

Q = magnitude of maximum distributed load (PSF)

Only LN and Q are required for UNIFORM distributed load

h. Horizontal Loads--One (1) to five (5) lines (numeric)

h(1) Control--One (1) line

(a) Contents

[LN] NPHOR NHORPR EQACC

(b) Definitions

NPHOR = number of horizontal line loads (0 to 4)

NHORPR = number of points for horizontal distribution = integers 0 or 2 to 12

EQACC = earthquake acceleration (G's), positive number, $0.0 \leq EQACC < 1.0$

h(2) Horizontal Line Loads--Zero (0) or one (1) line ([data] not required if NPHOR = 0) (numeric)

(a) Contents

[LN] [HOREL(1) PHOR(1)...HOREL(NPHOR) PHOR(NPHOR)]

(b) Definitions

HOREL(I) = elevation of Ith load (FT)

PHOR(I) = magnitude of Ith load (PLF)

h(3) Horizontal Pressure Distribution--Zero (0) to three (3) lines
([data] not required if NHORPR = 0) (numeric)
NHORPR pairs of values, four (4) pairs per line

(a) Contents

[LN] [ELPR(1) HORPR(1)...ELPR(NHORPR) HORPR(NHORPR)]

(b) Definitions

ELPR(I) = elevation of Ith pressure point (FT)

HORPR(I) = horizontal pressure at ELPR(I) (PSF)

Point numbers start at top point and proceed sequentially downward

Abbreviated Input Guide

16. Notation

a. Data items enclosed in brackets [ ] may not be required

b. Data items enclosed in braces { } indicate choose one (or more)

17. Input

a. Header--One (1) to four (4) lines

LN NLINES 'heading'

[LN 'heading']

[LN 'heading']

[LN 'heading']

b. Wall Type, Mode, Method--One (1) line

[LN] {CANTILEVER | ANCHORED} {DESIGN | ANALYSIS} [NMETH] [FR | FI | EB | EM | TE]

c. Wall Description--One (1) line

LN TOPEL {ANCHEL} {BOTEL} {EMOD} {SECMOM} {FS}

d. Rightside Soil Description--Three (3) to twenty-two (22) lines

d(1) Control--One (1) line

LN NSURRT NLAYRT

d(2) Rightside Surface Point Coordinates--One (1) to six (6) lines

LN SURELR(1) [SURELR(2)...SURELR(NSURRT)]
[LN XSURRT(2)...XSURRT(NSURRT)]

d(3) Rightside Soil Layer Data--One (1) to fifteen (15) lines

LN GAMRT(I) PHIRT(I) CRT(I) DELTRT(I) [ELLAYR(I) SLOPER(I)]

e. Leftside Soil Description--Three (3) to twenty-two (22) lines

e(1) Control--One (1) line

LN NSURLT NLAYLT

e(2) Leftside Surface Point Coordinates--One (1) to six (6) lines

LN SURELL(1) [SURELL(2)...SURELL(NSURLT)]
[LN XSURLT(2)...XSURLT(NSURLT)]

e(3) Leftside Soil Layer Data--One (1) to fifteen (15) lines

LN GAMLT(I) PHILT(I) CLT(I) DELTLT(I) [ELLAYL(I) SLOPEL(I)]

f. Water Data--One (1) line

LN WATELR WATELL GAMWAT SEEP

g. Vertical Loads on Rightside--One (1) to three (3) lines

g(1) Control--One (1) line

LN NPVERT { NONE | UNIFORM | STRIP | RAMP | TRIANGULAR }

g(2) Vertical Line Loads--Zero (0) or one (1) line

[LN XPVERT(1) PVERT(1)...XPVERT(NPVERT) PVERT(NPVERT)]

g(3) Distributed Vertical Load--Zero (0) or one (1) line

[LN {X1} {X2} {X3} Q]

h. Horizontal Loads--One (1) or two (2) lines

h(1) Control--One (1) line

LN NPHOR NHORPR EQACC

h(2) Horizontal Line Loads--Zero (0) or one (1) line

[LN HOREL(1) PHOR(1)...HOREL(NPHOR) PHOR(NPHOR)]

h(3) Horizontal Pressure Distribution--Zero (0) to three (3) lines

[LN ELPR(1) HORPR(1)...ELPR(NHORPR) HORPR(NHORPR)]

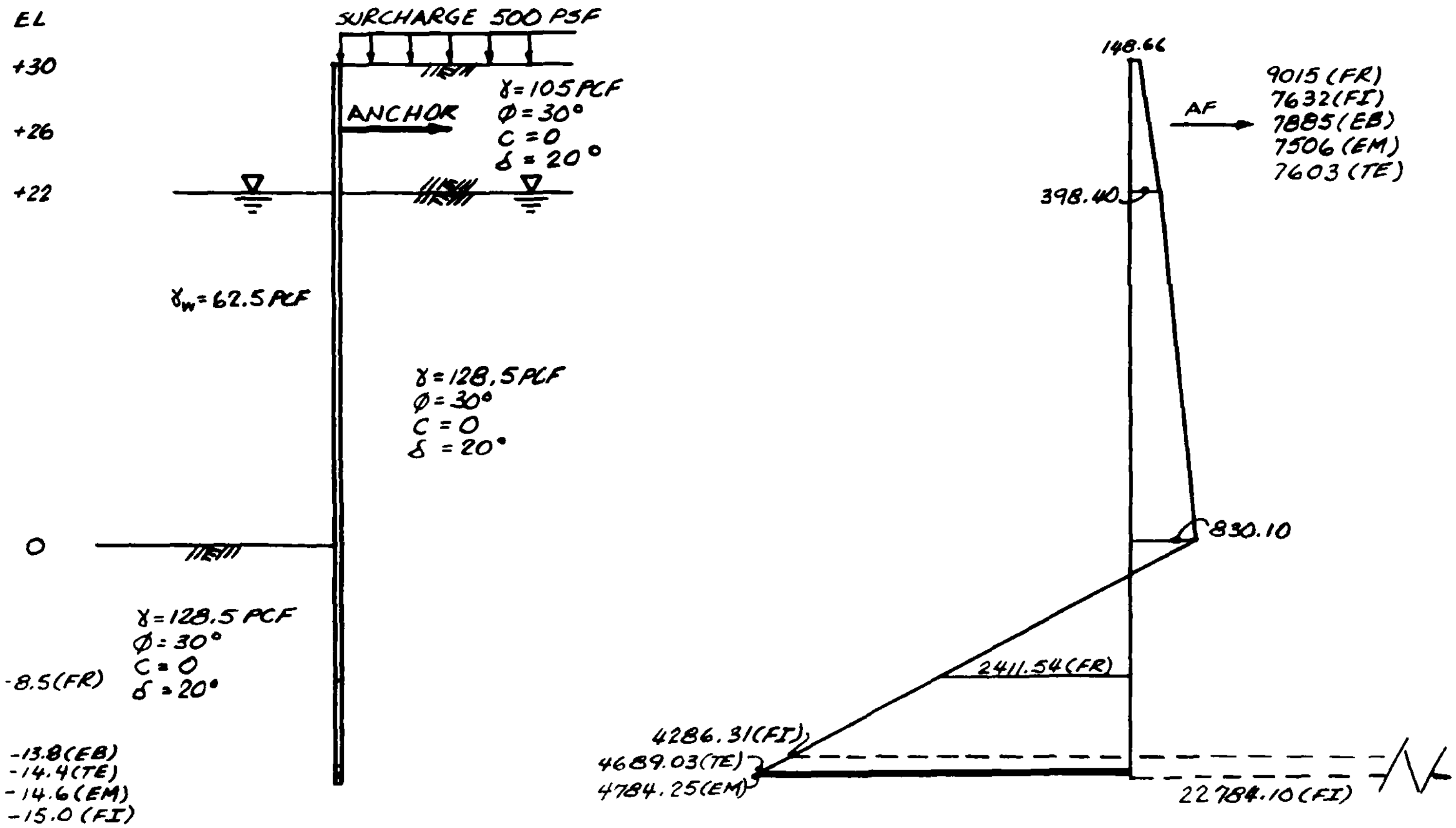
Appendix B: Problem "ANCH1"--Design Of an Anchored Wall on Granular Soil With Uniform Surcharge

1. The anchored wall shown in Figure B1a was designed by all five methods incorporated in the program. Input data were read from the file listed on page B5. An ehco of input data is shown on pages B6 and B7. Results are shown on pages B8-B19 along with program prompts to determine the type of data desired by the user. Results are plotted in Figures B1b-B1d.

2. A solution for design penetration of this wall by the free earth method is presented in Foundation Analysis and Design.* Hand calculations for design penetration, maximum bending moment, and anchor force for the free earth, equivalent beam, and equal moment methods are included on pages B20-B26. Differences between hand-calculated values and program results are attributable to truncation of the numerical values in the hand calculations.

---

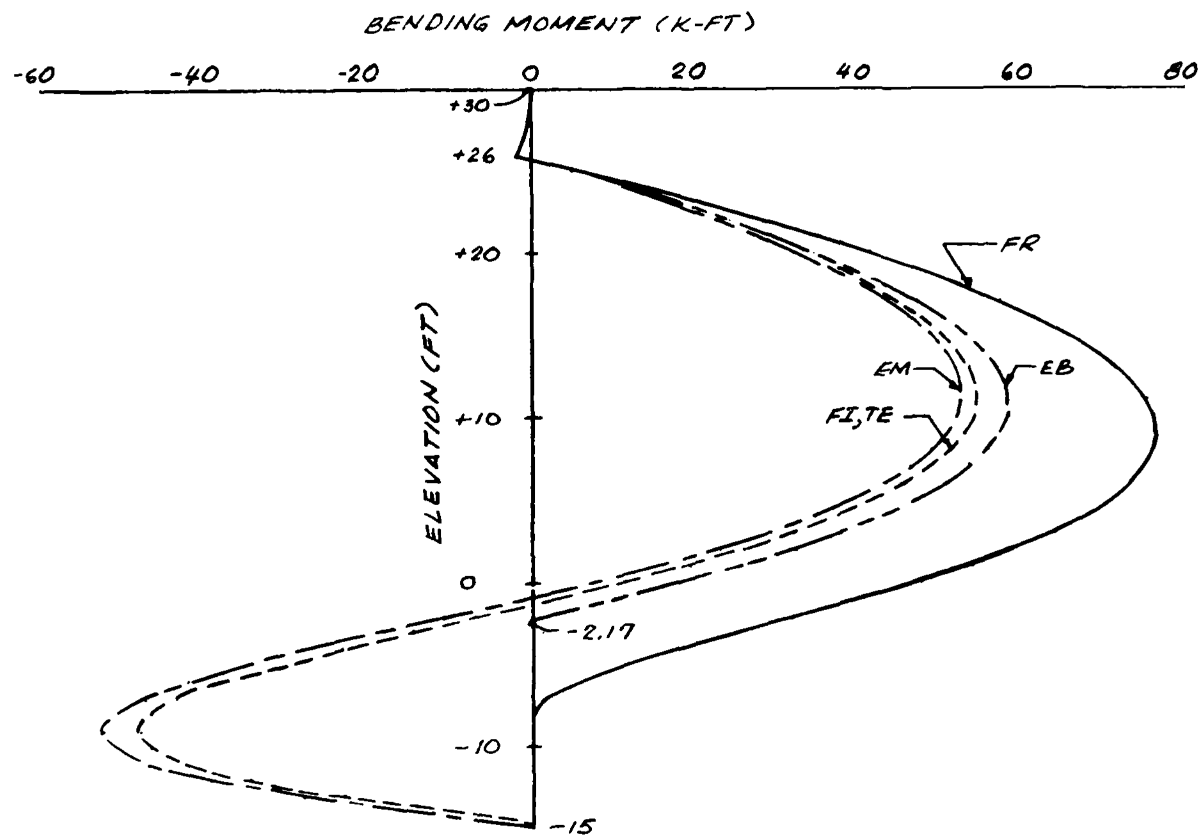
* Bowles, Joseph E. 1977. Foundation Analysis and Design, 2nd ed., McGraw-Hill, New York.



a. WALL AND SOIL

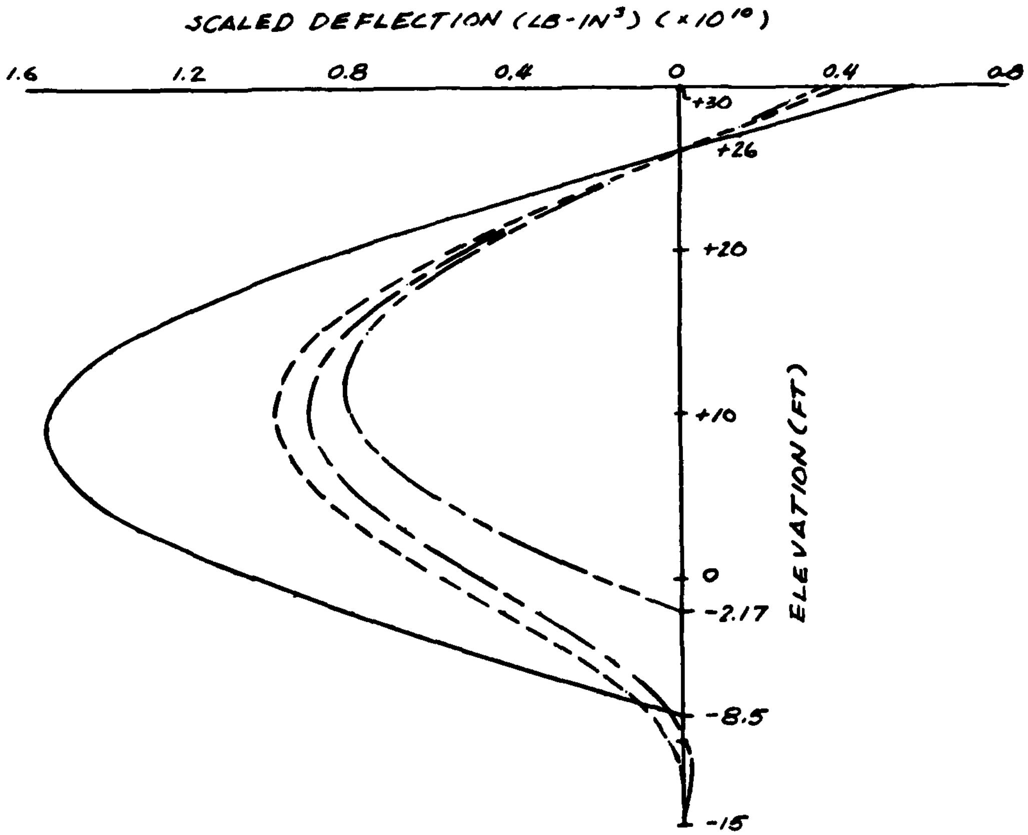
b. NET PRESSURE (PSF)

Figure B1. System and program results for problem "ANCH1" (sheet 1 of 3)



c. BENDING MOMENT

Figure B1. (sheet 2 of 3)



d. SCALED DEFLECTION

Figure B1. (sheet 3 of 3)

```
1000 3 PROBLEM - ANCH1 - ANCHORED WALL DESIGN - GRANULAR SOIL
1010 FROM 'FOUNDATION ANALYSIS AND DESIGN' BY J. E. BOWLES
1020 EXAMPLE 13-3, PP 29-431
1030 A D 5 FR FI EB EM TE
1040 30 26 1
1050 1 2
1060 30
1070 105 30 0 20 22 0
1080 128.5 30 0 20
1090 1 1
1100 0
1110 128.5 30 0 20
1120 22 22 62.5 1
1130 0 U
1140 500
1150 0 0 0
```

PROGRAM SHTWAL - DESIGN/ANALYSIS OF ANCHORED
OR CANTILEVER SHEET PILE WALLS BY CLASSICAL METHODS
DATE: 01/21/81 TIME: 10:47:16

1. INPUT DATA

1.A.--HEADING

PROBLEM - ANCH1 - ANCHORED WALL DESIGN - GRANULAR SOIL
FROM 'FOUNDATION ANALYSIS AND DESIGN' BY J. E. BOWLES
EXAMPLE 13-3, PP 29-431

1.B.--WALL TYPE, MODE, METHOD

ANCHORED WALL DESIGN BY FREE EARTH METHOD
ANCHORED WALL DESIGN BY FIXED EARTH METHOD
ANCHORED WALL DESIGN BY EQUIVALENT BEAM METHOD
ANCHORED WALL DESIGN BY EQUAL MOMENT METHOD
ANCHORED WALL DESIGN BY TERZAGHI METHOD

1.C.--WALL DESCRIPTION

TOP OF WALL ELEVATION = 30.00 (FT)
ANCHOR ELEVATION = 26.00 (FT)
FACTOR OF SAFETY = 1.00

1.D.--RIGHT SIDE SOIL DESCRIPTION

NUMBER OF RIGHT SIDE SURFACE POINTS = 1
NUMBER OF RIGHT SIDE SOIL LAYERS = 2

RIGHT SIDE SURFACE POINT COORDINATES

POINT NO.	ELEVATION (FT)	X-COORD (FT)
1	30.00	0.00

RIGHT SIDE SOIL LAYER DATA

LAYER NO.	UNIT WEIGHT (PCF)	INTERNAL FRICTION ANGLE (DEG)	COHESION (PSF)	WALL FRICTION ANGLE (DEG)	BOTTOM ELEV AT WALL (FT)	BOTTOM SLOPE (FT/FT)
1	105.00	30.00	0.00	20.00	22.00	1:0.0
2	128.50	30.00	0.00	20.00		

1.E.--LEFT SIDE SOIL DESCRIPTION
NUMBER OF LEFT SIDE SURFACE POINTS = 1
NUMBER OF LEFT SIDE SOIL LAYERS = 1

LEFT SIDE SURFACE POINT COORDINATES

POINT NO.	ELEVATION (FT)	X-COORD (FT)
1	0.00	0.00

LEFT SIDE SOIL LAYER DATA

LAYER NO.	UNIT WEIGHT (PCF)	INTERNAL FRICTION ANGLE (DEG)	COHESION (PSF)	WALL FRICTION ANGLE (DEG)	BOTTOM ELEV AT WALL (FT)	BOTTOM SLOPE (FT/FT)
1	128.50	30.00	0.00	20.00		

1.F.--WATER DATA
RIGHT SIDE ELEVATION = 22.00 (FT)
LEFT SIDE ELEVATION = 22.00 (FT)
WATER UNIT WEIGHT = 62.50 (PCF)
PRESSURE REDUCTION OPTION = 1

1.G.--SURCHARGE LOADS
NUMBER OF LINE LOADS = 0
DISTRIBUTED LOAD DISTRIBUTION = UNIF

UNIFORM SURCHARGE LOAD
LOAD = 500.00 PSF

1.H.--HORIZONTAL LOADS
NUMBER OF HORIZONTAL LINE LOADS = 0
NUMBER OF HORIZONTAL PRESSURE POINTS = 0
EARTHQUAKE ACCELERATION = 0.00 (G'S)

PROGRAM SHTWAL - DESIGN/ANALYSIS OF ANCHORED
OR CANTILEVER SHEET PILE WALLS BY CLASSICAL METHODS
DATE: 01/21/81 TIME: 11:00:07

2. RESULTS

2.A.--HEADING

PROBLEM - ANCH1 - ANCHORED WALL DESIGN - GRANULAR SOIL
FROM 'FOUNDATION ANALYSIS AND DESIGN' BY J. E. BOWLES
EXAMPLE 13-3, PP 29-431

2.B.--SUMMARY OF RESULTS FOR ANCHORED WALL DESIGN

SOIL PRESSURES DETERMINED BY COULOMB
COEFFICIENTS AND THEORY OF ELASTICITY
EQUATIONS FOR SURCHARGE LOADS

METHOD	WALL PEN (FT)	BOTTOM ELEV (FT)	MAXIMUM BENDING MOMENT (LB-FT)	MAX SCALED DEFLECTION (LB-IN3)	ANCHOR FORCE (LB)
FREE EARTH :	8.5	-8.5	76537.	1.56E+10	9015.
FIXED EARTH:	15.0	-15.0	54551.	9.96E+09	7632.
EQUIV BEAM :	13.8	-13.8	58348.	8.24E+09	7885.
EQUAL MOM :	14.6	-14.6	52690.	9.15E+09	7506.
TERZAGHI :	14.4	-14.4	54512.	9.95E+09	7630.

(NOTE: PENETRATION FOR EQUIVALENT BEAM
METHOD DOES NOT INCLUDE INCREASE
PRESCRIBED BY DRAFT EM 1110-2-2906)

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS
OF ELASTICITY IN PSI TIMES PILE MOMENT OF
INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES)

```
    DO YOU WANT COMPLETE RESULTS OUTPUT?
     ENTER 'YES' OR 'NO'
I>Y


    COMPLETE RESULTS ARE AVAILABLE FOR FOLLOWING
    METHODS OF ANALYSIS:
         FREE EARTH : ENTER 'FR' ON CUE
         FIXED EARTH: ENTER 'FI' ON CUE
         EQUIV BEAM : ENTER 'EB' ON CUE
         EQUAL MOM  : ENTER 'EM' ON CUE
         TERZAGHI   : ENTER 'TE' ON CUE


    ENTER METHOD FOR WHICH COMPLETE RESULTS ARE DESIRED
I>FR
```

2.C.--COMPLETE RESULTS FOR ANCHORED WALL DESIGN
BY FREE EARTH METHOD

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
30.00	0.	0.	-5.76E+09	148.66
29.00	-80.	-164.	-4.32E+09	179.87
28.00	-339.	-360.	-2.88E+09	211.09
27.00	-809.	-586.	-1.44E+09	242.31
26.00	-1522.	-844.	0.	273.53
26.00	-1522.	8171.	0.	273.53
25.00	6506.	7881.	1.44E+09	304.75
24.00	14230.	7561.	2.87E+09	335.96
23.00	21618.	7210.	4.28E+09	367.18
22.00	28639.	6827.	5.65E+09	398.40
21.00	35263.	6419.	6.97E+09	418.02
20.00	41470.	5991.	8.23E+09	437.65
19.00	47238.	5543.	9.42E+09	457.27
18.00	52550.	5076.	1.05E+10	476.89
17.00	57384.	4589.	1.15E+10	496.51
16.00	61722.	4083.	1.25E+10	516.14
15.00	65544.	3557.	1.33E+10	535.76
14.00	68830.	3012.	1.40E+10	555.38
13.00	71561.	2446.	1.45E+10	575.01
12.00	73716.	1862.	1.50E+10	594.63
11.00	75277.	1257.	1.53E+10	614.25
10.00	76224.	633.	1.55E+10	633.87
9.00	76537.	-11.	1.56E+10	653.50
8.00	76197.	-674.	1.55E+10	673.12
7.00	75183.	-1357.	1.53E+10	692.74
6.00	73476.	-2059.	1.50E+10	712.36
5.00	71058.	-2782.	1.45E+10	731.99
4.00	67907.	-3523.	1.40E+10	751.61
3.00	64004.	-4285.	1.33E+10	771.23
2.00	59331.	-5066.	1.24E+10	790.85
1.00	53866.	-5866.	1.15E+10	810.48
0.00	47591.	-6687.	1.05E+10	830.10

-1.00	40553.	-7325.	9.46E+09	446.77
-2.17	31814.	-7586.	8.11E+09	0.00
-3.00	25521.	-7452.	7.09E+09	-319.89
-4.00	18293.	-6940.	5.84E+09	-703.22
-5.00	11768.	-6046.	4.55E+09	-1086.55
-6.00	6329.	-4767.	3.24E+09	-1469.88
-7.00	2361.	-3106.	1.93E+09	-1853.22
-8.00	245.	-1061.	6.04E+08	-2236.55
-8.46	0.	-0.	0.	-2411.54

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS
OF ELASTICITY IN PSI TIMES PILE MOMENT OF
INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES)

DO YOU WANT RESULTS FOR ANOTHER METHOD? ENTER 'YES' OR 'NO'
I>Y

ENTER METHOD FOR WHICH COMPLETE RESULTS ARE DESIRED

2.C.--COMPLETE RESULTS FOR ANCHORED WALL DESIGN
BY FIXED EARTH METHOD

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
30.00	0.	0.	-3.97E+09	148.66
29.00	-80.	-164.	-2.98E+09	179.87
28.00	-339.	-360.	-1.99E+09	211.09
27.00	-809.	-586.	-9.93E+08	242.31
26.00	-1522.	-844.	0.	273.53
26.00	-1522.	6788.	0.	273.53
25.00	5124.	6499.	9.94E+08	304.75
24.00	11465.	6179.	1.98E+09	335.96
23.00	17470.	5827.	2.94E+09	367.18
22.00	23109.	5444.	3.88E+09	398.40
21.00	28350.	5036.	4.77E+09	418.02
20.00	33174.	4608.	5.62E+09	437.65
19.00	37560.	4161.	6.41E+09	457.27
18.00	41489.	3694.	7.13E+09	476.89
17.00	44940.	3207.	7.79E+09	496.51
16.00	47896.	2701.	8.36E+09	516.14
15.00	50335.	2175.	8.85E+09	535.76
14.00	52238.	1629.	9.26E+09	555.38
13.00	53586.	1064.	9.57E+09	575.01
12.00	54359.	479.	9.80E+09	594.63
11.20	54551.	0.	9.90E+09	610.23
11.00	54538.	-125.	9.93E+09	614.25
10.00	54102.	-749.	9.96E+09	633.87
9.00	53032.	-1393.	9.90E+09	653.50
8.00	51309.	-2056.	9.75E+09	673.12
7.00	48913.	-2739.	9.51E+09	692.74
6.00	45824.	-3442.	9.19E+09	712.36
5.00	42022.	-4164.	8.79E+09	731.99
4.00	37489.	-4906.	8.31E+09	751.61
3.00	32204.	-5667.	7.77E+09	771.23
2.00	26148.	-6448.	7.18E+09	790.85
1.00	19301.	-7249.	6.54E+09	810.48
0.00	11643.	-8069.	5.86E+09	830.10
-1.00	3222	-8708.	5.17E+09	446.77

-2.17	-7129.	-8968.	4.36E+09	0.00
-3.00	-14576.	-8835.	3.78E+09	-319.89
-4.00	-23186.	-8323.	3.12E+09	-703.22
-5.00	-31094.	-7428.	2.49E+09	-1086.55
-6.00	-37915.	-6150.	1.92E+09	-1469.88
-7.00	-43266.	-4488.	1.42E+09	-1853.22
-8.00	-46764.	-2444.	9.88E+08	-2236.55
-9.00	-48026.	-15.	6.38E+08	-2619.88
-10.00	-46667.	2796.	3.71E+08	-3003.21
-11.00	-42306.	5991.	1.83E+08	-3386.54
-12.00	-34557.	9569.	6.85E+07	-3769.87
-13.00	-23039.	13531.	1.30E+07	-4153.20
-13.35	-18088.	14996.	4.09E+06	-4286.31
-13.60	-14144.	15546.	0.	0.00
-14.97	0.	0.	-4.55E+06	22784.10

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS
OF ELASTICITY IN PSI TIMES PILE MOMENT OF
INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES)

```
    DO YOU WANT RESULTS FOR ANOTHER METHOD? ENTER 'YES' OR 'NO'
I>Y
    ENTER METHOD FOR WHICH COMPLETE RESULTS ARE DESIRED
I>EB
```

2.C.--COMPLETE RESULTS FOR ANCHORED WALL DESIGN
BY EQUIV BEAM METHOD

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
30.00	-0.	0.	-3.58E+09	148.66
29.00	-80.	-164.	-2.69E+09	179.87
28.00	-339.	-360.	-1.79E+09	211.09
27.00	-809.	-586.	-8.96E+08	242.31
26.00	-1522.	-844.	0.	273.53
26.00	-1522.	7041.	0.	273.53
25.00	5377.	6752.	8.97E+08	304.75
24.00	11971.	6432.	1.78E+09	335.96
23.00	18230.	6080.	2.65E+09	367.18
22.00	24121.	5697.	3.49E+09	398.40
21.00	29616.	5289.	4.28E+09	418.02
20.00	34692.	4861.	5.02E+09	437.65
19.00	39332.	4414.	5.71E+09	457.27
18.00	43513.	3947.	6.32E+09	476.89
17.00	47218.	3460.	6.86E+09	496.51
16.00	50427.	2954.	7.32E+09	516.14
15.00	53119.	2428.	7.69E+09	535.76
14.00	55276.	1882.	7.97E+09	555.38
13.00	56877.	1317.	8.15E+09	575.01
12.00	57903.	732.	8.24E+09	594.63
11.00	58334.	128.	8.23E+09	614.25
10.79	58348.	0.	8.20E+09	618.32
10.00	58152.	-496.	8.11E+09	633.87
9.00	57335.	-1140.	7.90E+09	653.50

8.00	55865.	-1803.	7.58E+09	673.12
7.00	53722.	-2486.	7.17E+09	692.74
6.00	50886.	-3189.	6.67E+09	712.36
5.00	47337.	-3911.	6.08E+09	731.99
4.00	43057.	-4653.	5.41E+09	751.61
3.00	38025.	-5414.	4.66E+09	771.23
2.00	32222.	-6195.	3.85E+09	790.85
1.00	25628.	-6996.	2.98E+09	810.48
0.00	18224.	-7816.	2.06E+09	830.10
-1.00	10056.	-8455.	1.12E+09	446.77
-2.17	0.	-8715.	0.	0.00

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS
OF ELASTICITY IN PSI TIMES PILE MOMENT OF
INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES)

(NOTE: OUTPUT TABLE FOR EQUIVALENT BEAM
METHOD ENDS AT ASSUMED POINT OF INFLECTION)

DO YOU WANT RESULTS FOR ANOTHER METHOD? ENTER 'YES' OR 'NO'

```
I>Y
    ENTER METHOD FOR WHICH COMPLETE RESULTS ARE DESIRED
I>EM
```

2.C.--COMPLETE RESULTS FOR ANCHORED WALL DESIGN
BY EQUAL MOM METHOD

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
30.00	-0.	0.	-3.73E+09	148.66
29.00	-80.	-164.	-2.80E+09	179.87
28.00	-339.	-360.	-1.86E+09	211.09
27.00	-809.	-586.	-9.33E+08	242.31
26.00	-1522.	-844.	0.	273.53
26.00	-1522.	6661.	0.	273.53
25.00	4997.	6372.	9.34E+08	304.75
24.00	11212.	6052.	1.86E+09	335.96
23.00	17090.	5700.	2.76E+09	367.18
22.00	22602.	5317.	3.64E+09	398.40
21.00	27717.	4909.	4.48E+09	418.02
20.00	32414.	4481.	5.27E+09	437.65
19.00	36673.	4034.	6.00E+09	457.27
18.00	40475.	3567.	6.67E+09	476.89
17.00	43801.	3080.	7.27E+09	496.51
16.00	46629.	2574.	7.80E+09	516.14
15.00	48942.	2048.	8.24E+09	535.76
14.00	50718.	1502.	8.60E+09	555.38
13.00	51940.	937.	8.87E+09	575.01
12.00	52586.	352.	9.05E+09	594.63
11.41	52690.	0.	9.11E+09	606.14
11.00	52638.	-252.	9.15E+09	614.25
10.00	52076.	-876.	9.15E+09	633.87
9.00	50879.	-1520.	9.06E+09	653.50
8.00	49029.	-2183.	8.88E+09	673.12
7.00	46506.	-2866.	8.62E+09	692.74
6.00	43291.	-3569.	8.28E+09	712.36
5.00	39363.	-4291.	7.86E+09	731.99
4.00	34702.	-5033.	7.38E+09	751.61
3.00	29291.	-5794.	6.83E+09	771.23
2.00	23108.	-6575.	6.24E+09	790.85
1.00	16134.	-7376.	5.60E+09	810.48
0.00	8350.	-8196.	4.94E+09	830.10

-1.00	-197.	-8834.	4.26E+09	446.77
-2.17	-10696.	-9095.	3.48E+09	0.00
-3.00	-18249.	-8961.	2.93E+09	-319.89
-4.00	-26986.	-8450.	2.30E+09	-703.22
-5.00	-35020.	-7555.	1.72E+09	-1086.55
-6.00	-41968.	-6277.	1.20E+09	-1469.88
-7.00	-47446.	-4615.	7.45E+08	-1853.22
-8.00	-51071.	-2570.	3.77E+08	-2236.55
-9.00	-52459.	-142.	9.75E+07	-2619.88
-10.00	-51227.	2670.	-9.23E+07	-3003.21
-11.00	-46992.	5864.	-1.94E+08	-3386.54
-12.00	-39370.	9443.	-2.15E+08	-3769.87
-13.00	-27979.	13404.	-1.68E+08	-4153.20
-14.00	-12434.	17749.	-7.40E+07	-4536.53
-14.65	0.	20761.	0.	-4784.25

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS
OF ELASTICITY IN PSI TIMES PILE MOMENT OF
INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES)

```
    DO YOU WANT RESULTS FOR ANOTHER METHOD? ENTER 'YES' OR 'NO'
I>Y
    ENTER METHOD FOR WHICH COMPLETE RESULTS ARE DESIRED
I>TE
```

2.C.--COMPLETE RESULTS FOR ANCHORED WALL DESIGN
BY TERZAGHI METHOD

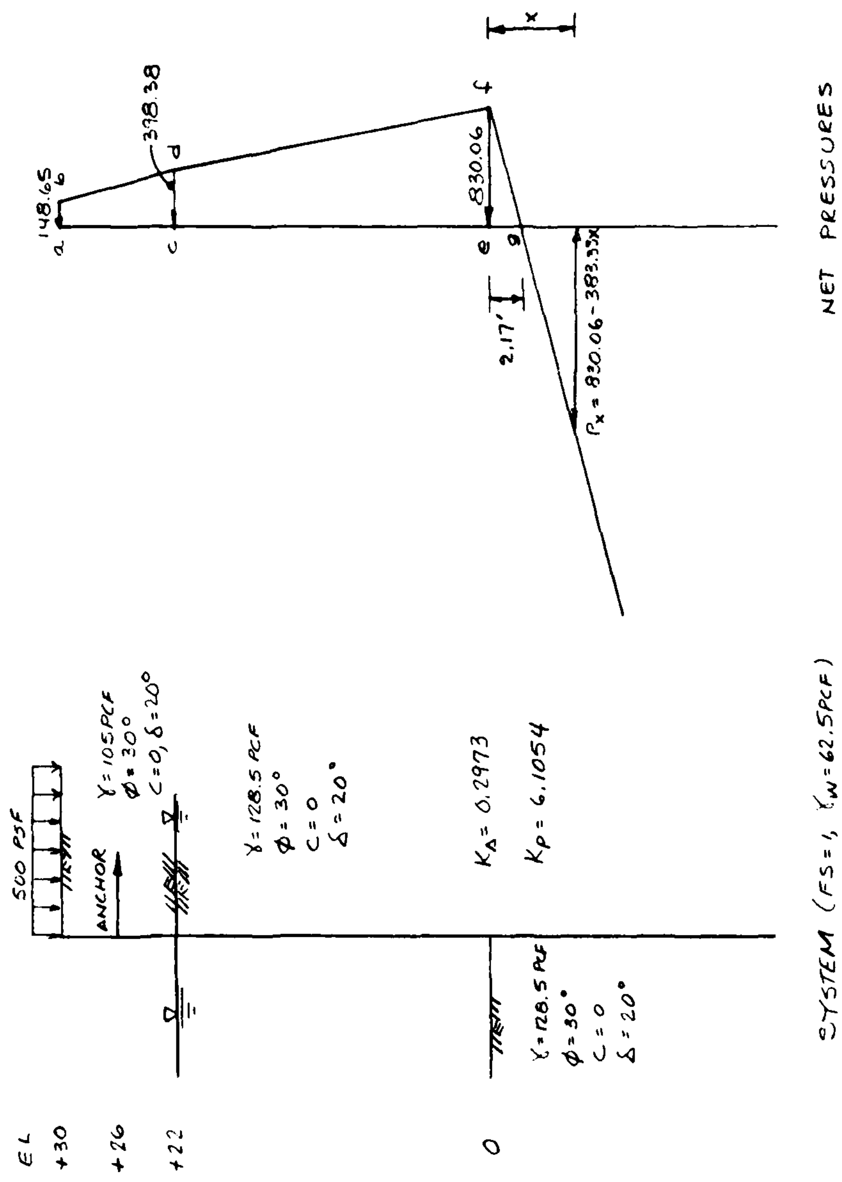
ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
30.00	-0.	0.	-3.96E+09	148.66
29.00	-80.	-164.	-2.97E+09	179.87
28.00	-339.	-360.	-1.98E+09	211.09
27.00	-809.	-586.	-9.92E+08	242.31
26.00	-1522.	-844.	0.	273.53
26.00	-1522.	6785.	0.	273.53
25.00	5121.	6496.	9.93E+08	304.75
24.00	11460.	6176.	1.98E+09	335.96
23.00	17463.	5824.	2.94E+09	367.18
22.00	23098.	5442.	3.87E+09	398.40
21.00	28337.	5033.	4.77E+09	418.02
20.00	33158.	4605.	5.61E+09	437.65
19.00	37541.	4158.	6.40E+09	457.27
18.00	41468.	3691.	7.13E+09	476.89
17.00	44917.	3204.	7.78E+09	496.51
16.00	47869.	2698.	8.35E+09	516.14
15.00	50306.	2172.	8.84E+09	535.76
14.00	52207.	1626.	9.25E+09	555.38
13.00	53552.	1061.	9.56E+09	575.01
12.00	54323.	476.	9.78E+09	594.63
11.21	54512.	0.	9.88E+09	610.15
11.00	54498.	-128.	9.91E+09	614.25
10.00	54060.	-752.	9.95E+09	633.87
9.00	52988.	-1396.	9.89E+09	653.50
8.00	51262.	-2059.	9.74E+09	673.12
7.00	48863.	-2742.	9.50E+09	692.74
6.00	45771.	-3445.	9.17E+09	712.36
5.00	41967.	-4167.	8.77E+09	731.99
4.00	37431.	-4909.	8.30E+09	751.61
3.00	32143.	-5670.	7.76E+09	771.23
2.00	26084.	-6451.	7.16E+09	790.85
1.00	19235.	-7252.	6.52E+09	810.48
0.00	11575.	-8072.	5.85E+09	830.10

-1.00	3151.	-8710.	5.16E+09	446.77
-2.17	-7203.	-8971.	4.34E+09	0.00
-3.00	-14652.	-8837.	3.77E+09	-319.89
-4.00	-23265.	-8326.	3.11E+09	-703.22
-5.00	-31176.	-7431.	2.48E+09	-1086.55
-6.00	-37999.	-6153.	1.91E+09	-1469.88
-7.00	-43353.	-4491.	1.41E+09	-1853.22
-8.00	-46854.	-2446.	9.80E+08	-2236.55
-9.00	-48118.	-18.	6.31E+08	-2619.88
-10.00	-46762.	2794.	3.66E+08	-3003.21
-11.00	-42403.	5988.	1.80E+08	-3386.54
-12.00	-34657.	9567.	6.75E+07	-3769.87
-13.00	-23142.	13528.	1.42E+07	-4153.20
-14.00	-7473.	17873.	3.49E+05	-4536.53
-14.40	0.	19708.	0.	-4689.03

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS
OF ELASTICITY IN PSI TIMES PILE MOMENT OF
INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES)

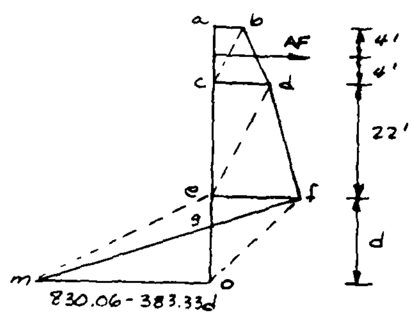
```
    DO YOU WANT RESULTS FOR ANOTHER METHOD? ENTER 'YES' OR 'NO'
I>N
    DO YOU WANT GEOMETRY AND/OR RESULTS PLOTTED?
    ENTER 'GEOMETRY', 'RESULTS', 'BOTH', OR 'NEITHER'
I>N
```

Verification of Problem "ANCH1" (Sheet 1 of 7)



Verification of Problem "ANCH1" (Sheet 2 of 7)

DESIGN BY FREE EARTH METHOD



FORCE	PRESS DIAG	FACTORS	MOMENT ARM ABOUT AF	MOMENT ABOUT AF
P_1	abc	(148.65)(8)/2 = 594.60	8/3 − 4 = −1.33	−790.82
P_2	bcd	(398.38)(8)/2 = 1573.52	16/3 − 4 = 1.33	2092.78
P_3	cde	(398.38)(22)/2 = 4382.18	22/3 + 4 = 11.33	49650.10
P_4	def	(830.06)(22)/2 = 9130.66	44/3 + 4 = 18.67	170469.42
P_5	efo	(830.06)d/2 = 415.03d	26 + 0.33d	$10790.78d + 136.96d^2$
P_6	emo	(830.06 − 383.33d)(d)/2 = $415.03d - 191.67d^2$	26 + 0.67d	$10790.78d$ $-4705.35d^2$ $-128.42d^3$

$$\Sigma F_H = 15680.96 + 830.06\,d - 191.67\,d^2 - AF$$

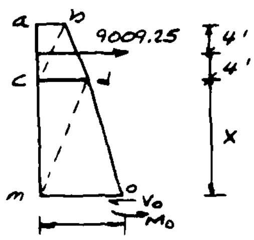
$$\Sigma M_{AF} = 221421.48 + 21581.56d - 4568.39d^2 - 128.42d^3$$

FOR $\Sigma M_{AF} = 0$:

TRIAL d	ΣM	
8	35946	
9	−48002	
INTERPOLATE $d = 8 + 35946/(35946+48002)$		
8.43	1768	
8.44	939	
8.45	109	← SAY OK (PROGRAM 8.46)
8.46	−723	(BOWLES 8.5)

FROM $\Sigma F_H = 0$: AF = 9009.25 (PROGRAM 9015 LB)
(BOWLES 9.1 KIP)

MAXIMUM MOMENT FOR FREE EARTH METHOD
MAXIMUM BETWEEN POINTS C AND O FIGURE SHEET 1 OF



$P_x = (500 + 8(105) + 66x)\,K_A = 398.38 + 19.62x$

FORCE	PRESS DIAG	FACTORS	MOMENT ARM ABOUT O	MOMENT ABOUT O
P1	abc	594.60	$x + 5.33$	$3169.22 + 594.60x$
P2	bcd	1573.52	$x + 2.67$	$4201.30 + 1573.52x$
P3	cdm	$398.38(x)/2 = 199.19x$	$0.67x$	$133.46x^2$
P4	dmo	$(398.38 + 19.62x)(x)/2 = 199.19x + 9.81x^2$	$0.33x$	$65.73x^2 + 3.24x^3$
AF		-9009.25	$x + 4$	$-36037 - 9009.25x$

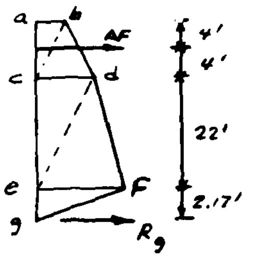
$V_o = -\Sigma P = 6841.13 - 398.38x - 9.81x^2$

$M_o = -\Sigma M = 28666.48 + 6841.13x - 199.19x^2 - 3.24x^3$

FOR $V_o = 0$ $\quad x = \dfrac{398.38 \pm \sqrt{(398.38)^2 - 4(-9.81)(6841.13)}}{2(-9.81)} = 13.01'$

$M_o = M_{MAX} = 76820$ #-FT (PROGRAM 76537)

DESIGN BY EQUIVALENT BEAM METHOD
ASSUME POINT OF INFLECTION AT POINT g FIGURE SHEET 1



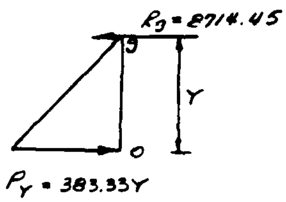
FORCE	PRESS DIAG	FACTORS	MOMENT ARM ABOUT AF	MOMENT ABOUT AF
F1	abc	594.60	-1.33	-790.82
F2	bcd	1573.52	1.33	2092.78
P3	cde	4382.18	11.33	49650.10
P4	def	9130.66	18.67	170469.42
F5	efg	(830.06)(2.17)/2 = 900.62	26.72	24064.57
AF		- AF	0	0
R_g		$- R_g$	28.17	$-28.17 R_g$

ΣF_H = 16581.58 - AF - R_g

ΣM_{AF} = 245486.05 - 28.17 R_g $\quad\therefore$ R_g = 8714.45#
AF = 7867.13#
(PROGRAM 7885#)

Verification of Problem "ANCH1" (Sheet 5 of 7)

PENETRATION BY EQUIVALENT BEAM METHOD



$$\Sigma M_0 = 8714.45Y - (383.33Y)(Y/2)(Y/3) = 0$$

$$\therefore Y = 11.68'$$

$$d = 11.68 + 2.17 = 13.85' \quad (\text{PROGRAM } 13.8')$$

MAXIMUM MOMENT FOR EQUIV. BEAM METHOD
USE FACTORS FROM FREE EARTH METHOD WITH AF = 7867.15#

$$V_0 = 5699.01 - 398.38X - 9.81X^2$$

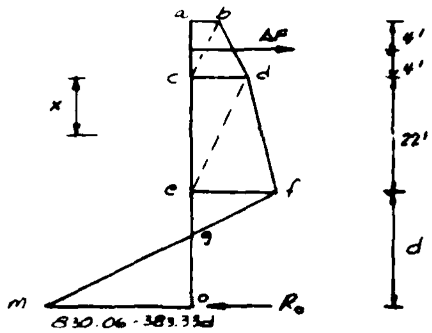
$$M_0 = 24098.00 + 5699.01X - 199.19X^2 - 3.24X^3$$

$$\text{FOR } V_0 = 0 \qquad X = \frac{398.38 \pm \sqrt{(398.38)^2 - 4(-9.81)(5699.01)}}{2(-9.81)}$$

$$X = 11.21'$$

$$M_0 = M_{MAX} = 58387^{\#\text{-FT}} \quad (\text{PROGRAM } 58348^{\#\text{-FT}})$$

DESIGN BY EQUAL MOMENT METHOD



FROM FREE EARTH METHOD AND ABOVE

$$\Sigma M_{\Delta F} = 221421.48 + 21581.56d - 4568.39d^2 - 128.42d^3 + (26+d)R_o = 0 \quad (1)$$

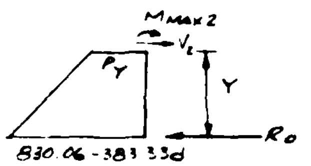
$$\Sigma F_H = -5680.76 + 830.06d - 191.67d^2 - \Delta F + R_o = 0 \quad (2)$$

MAXIMUM MOMENT ABOVE e FROM FREE EARTH METHOD

MAX OCCURS AT $$x = \frac{398.38 - \sqrt{(398.38)^2 - 4(-9.81)(-2168.12 + \Delta F)}}{2(-9.81)} \quad (3)$$

$$M_{MAX\,1} = 4\Delta F - 7370.52 + (\Delta F - 2168.12)x - 199.19x^2 \;\; 3.24x^3 \quad (4)$$

FOR MAXIMUM MOMENT BELOW e



$$P_Y = 830.06 - 383.33(d - Y)$$

FOR $V_2 = 0$ $$[830.06 - 383.33(d - Y)]Y/2 + [830.06 - 383.33d]Y/2 + R_o = 0$$

OR $$Y = \frac{(383.33d - 830.06) \pm \sqrt{(383.33d - 830.06)^2 - 4(191.67)R_o}}{2(191.67)} \quad (5)$$

THEN

$$M_{MAX\,2} = (415.03 - 191.67d + 127.78Y)Y^2 \quad (6)$$

Verification of Problem "ANCH1" (Sheet 7 of 7)

PROCEDURE FOR DETERMINING d BY EQUAL MOM. METHOD

1. ASSUME d
2. CALCULATE R_0 FROM EQN ①
3. CALCULATE ΔF FROM EQN ②
4. CALCULATE X FROM EQN ③
5. CALCULATE M_{MAX1} FROM EQN ④
6. CALCULATE Y FROM EQN ⑤
7. CALCULATE M_{MAX2} FROM EQN ⑥
8. REPEAT UNTIL $|M_{MAX1}| = |M_{MAX2}|$

TRIAL d	R_0	ΔF	X	M_{MAX1}	Y	M_{MAX2}	
13'	14159.36	8238.87	11.81	64161	4.24	-27594	
14'	18105.64	7840.12	11.17	57978	5.08	-41786	) *)
15'	22348.37	7581.48	10.66	53369	5.90	-59390	
14.73'	21171.88	7492.43	10.60	52797	5.68	-54281	*
14.67	20913.99	7522.84	10.65	53242	5.63	-58167	OK

(PROGRAM d = 14.65', AF = 7502#, M_{MAX} = 52638 #')

* INTERPOLATE

d = 14' $M_{MAX1} + M_{MAX2}$ = 16192

d = 15' $M_{MAX1} + M_{MAX2}$ = -6021

$d = 14 + 16192/(16192 + 6021) = 14.73$

d = 14' $M_{MAX1} + M_{MAX2}$ = 16192

d = 14.73' $M_{MAX1} + M_{MAX2}$ = -1484

$d = 14 + 0.73[16192/(16192+1484)] = 14.67$

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.

George, Michael E.
User's guide: Computer program for design and analysis of sheet pile walls by classical methods (CSHTWAL) : Report 2 : Interactive graphics options / by Michael E. George (Automatic Data Processing Center, U.S. Army Engineer Waterways Experiment Station) ; prepared for Office, Chief of Engineers, U.S. Army. -- Vicksburg, Miss. : U.S. Army Engineer Waterways Experiment Station ; Springfield, Va. : available from NTIS, 1981.
36, [44] p. : ill. ; 27 cm. -- (Instruction report / U.S. Army Engineer Waterways Experiment Station ; K-81-2, Report
Cover title.
"March 1981."
"A report under the Computer-Aided Structural Engineering (CASE) Project."

1. Computer graphics. 2. Computer programs. 3. CSHTWAL (Computer program). 4. Electronic data. 5. Sheet - piling. 6. Steel piling. I. United States.

George, Michael E.
User's guide: Computer program for design : ... 1981.
(Card 2)

Army. Corps of Engineers. Office of the Chief of Engineers. III. United States. Army Engineer Waterways Experiment Station. Automatic Data Processing Center. IV. Title V. Series: Instruction report (United States. Army Engineer Waterways Experiment Station) ; K-81-2, Report 2.
TA7.W34i no.K-81-2, Report 2

WATERWAYS EXPERIMENT STATION REPORTS PUBLISHED UNDER THE COMPUTER-AIDED STRUCTURAL ENGINEERING (CASE) PROJECT

	Title	Date
Technical Report K-78-1	List of Computer Programs for Computer-Aided Structural Engineering	[illegible]
Instruction Report O-79-2	User's Guide: Computer Program with Interactive Graphics for Analysis of Plane Frame Structures (CFRAME)	[illegible]
Technical Report K-80-1	Survey of Bridge-Oriented Design [illegible]	[illegible]
Technical Report K-80-2	Evaluation of Computer Programs for the Design/Analysis of [illegible]	[illegible]
[illegible] Report K-80-[illegible]	User's Guide: [illegible] of Cantilever [illegible]	[illegible]
[illegible]	A Three-Dim[illegible] [illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible] (...TA)	[illegible]
[illegible] Report K-81-4	[illegible]	[illegible]
Instruction Report K-81-6	User's Guide: Computer Program for Optimum Nonlinear Dynamic Design of Reinforced Concrete Slabs Under Blast Loading (CBARCS)	[illegible]
Instruction Report K-81-7	User's Guide: Computer Program for Design or Investigation of Orthogonal Culverts (CORTCUL)	Mar 1981

DAT
FILME
7