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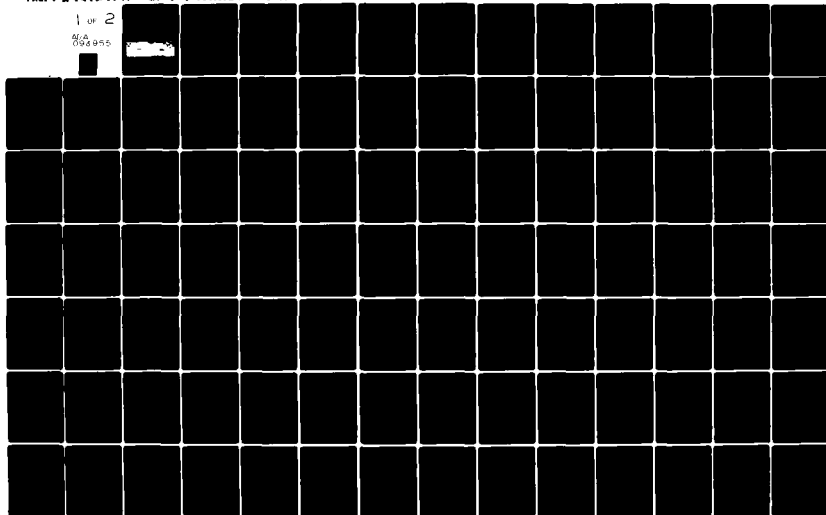
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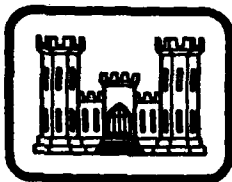
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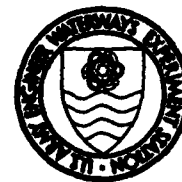
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INSTRUCTION REPORT K-80-5

COMPUTER PROGRAMS FOR SETTLEMENT ANALYSIS

by

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U. S. Army Engineer Waterways Experiment Station
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October 1980

Final Report

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Prepared for U. S. Army Engineer Division, Lower Mississippi Valley
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report documents and gives example runs of three computer programs for performing settlement analysis of foundations and embankments. The programs are 10016, MAGSETII, and FD31. Program 10016, which was developed by Mr. Douglas Spaulding, St. Paul District, determines vertical stresses beneath footings and embankments. MAGSETII was written by Messrs. R. L. Schiffman, D. M. Jubenville, and V. Partyka of the University of Colorado to calculate the magnitudes of settlement of multilayered soil systems. Dr. Roy E. Olson, University of Texas at Austin, developed FD31 to determine time-settlement. (Continued)		

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20. ABSTRACT (Continued)

relationships for cohesive soils due to large uniformly distributed loads.

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PREFACE

This report provides documentation of three computer programs for performing settlement analysis of foundations and embankments. The report was written as part of the normal operation of the joint U. S. Army Engineer Waterways Experiment Station (WES) and U. S. Army Engineer Division, Lower Mississippi Valley, Computer Center for Fiscal Years 1978 and 1979.

The three computer programs documented herein are I0016, MAGSETII and FD31. Program I0016, which was developed by Mr. Douglas Spaulding, Foundation, Materials, and Survey Branch, St. Paul District, determines vertical stresses beneath footings and embankments. MAGSETII was written by Messrs. R. L. Schiffman, D. M. Jubenville, and V. Partyka of the University of Colorado to calculate the magnitudes of settlement of multilayered soil systems. Dr. Roy E. Olson, University of Texas, Austin, developed FD31 to determine time-settlement relationships for cohesive soils due to large uniformly distributed loads.

The documentation was put together in a package, with example runs and comparisons with hand computations, by Mr. Reed L. Mosher, Computer-Aided Design Group, Automatic Data Processing (ADP) Center, WES, under the direct supervision of Dr. N. Radhakrishnan, Special Technical Assistant, ADP Center. This report was written by Mr. Mosher and Dr. Radhakrishnan. Mr. D. 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 preparation of this report. 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
kips (1000 lb force)	4.448222	kilonewtons
kips (force) per square foot	47.88026	kilopascals
pounds (force) per square foot	47.88026	pascals
pounds (mass) per cubic foot	16.01846	kilograms per cubic metre
square feet	0.09290304	square metres

PROGRAM INFORMATION

This settlement package described herein is operational on the U. S. Army Engineer Waterways Experiment Station's Honeywell G-635 time-sharing system at Vicksburg, Miss., and on the Office of Personnel Management's Honeywell 6000 Series time-sharing system at Macon, Ga. The file names used for the programs are listed below with short descriptions of how to access each. It is assumed that the user knows how to sign on to the system he is using.

I0016

* FORT

* RUN WESLIB/CORPS/I0016,R

MAGSETII

* FORT

* RUN WESLIB/CORPS/I0010,R

FD31

* FORT

* RUN WESLIB/CORPS/I0011,R

COMPUTER PROGRAMS FOR SETTLEMENT ANALYSIS

PART I: INTRODUCTION

Purpose

1. A package of three programs for performing settlement analysis of foundations and embankments is documented in this report. The programs are based on theories and methods accepted by practicing engineers and presented in universities throughout the United States.

2. The package can be a very powerful and time saving aid to the foundation engineer in the analysis of complex foundation systems. Without the use of the computer, solutions to problems involving such systems could be lengthy and tedious and leave room for human error. The programs allow the foundation engineer to be more creative by providing more time to explore innovative alternatives.

Programs in the Package

3. The package consists of three separate programs: I0016, MAGSETII, and FD31. I0016 determines vertical stresses beneath footings and embankments. It was developed by Douglas Spaulding (1968) of the St. Paul District. MAGSETII calculates the magnitudes of settlement of multilayered soil systems. It was written by R. L. Schiffman, D. M. Jubenville, and V. Partyka (1976) at the University of Colorado. Additions to the program to compute the degree of consolidation have been made. FD31 develops time-settlement relationships for cohesive soils due to large uniformly distributed loads. It was written by Roy Olson at the University of Texas at Austin.

Scope

4. This report provides documentation for the three computer

programs used in the package. Theories on which the programs are based, along with capabilities of the programs, are discussed. Input/output for the programs is discussed using three example problems. One of the example problems is taken from Engineer Manual 1110-2-1904 (Headquarters, Department of the Army, Office of the Chief of Engineers 1953). Documentation for the programs, as provided by the original authors, is referenced in this report. Original documentation for the programs can be obtained from the Engineering Computer Program Library (ECPL) at the U. S. Army Engineer Waterways Experiment Station (WES).

PART II: METHODS AND CAPABILITIES

Program I0016

5. Program I0016 can calculate vertical stress distributions in a soil profile based on either Boussinesq or Westergaard solutions. Both methods assume that the soil is homogeneous, isotropic, and linearly elastic. Westergaard further assumes that there are no lateral deformations. These assumptions do not completely model actual soil behavior, but without these assumptions solutions are only possible using more sophisticated techniques. In most cases, the results obtained using these simplified assumptions are reasonably accurate when compared to field observations (see Spaulding 1968). I0016 allows the user to analyze rectangular loadings and/or embankment loadings in a three-dimensional layout. The embankment loadings are applied by number of uniform rectangular shaped layers with the width decreasing with height. This allows the user to consider problems involving time-dependent loads due to construction, etc. The user has the option to choose the horizontal or vertical plane to be investigated. The capabilities are illustrated best in the example problems presented in Part III.

Program MAGSETII

6. Program MAGSETII utilizes Terzaghi's one-dimensional consolidation theory, simplified to apply to a two-dimensional condition, for estimating settlements in cohesive soils. The effective stress history for each layer or for the total profile can be input to the program. The program applies a vertical stress influence factor, due to the loading, to the effective stress history. Under this effective stress history, some very complex loadings can be accounted for, such as: unloading due to excavation, temporary and/or permanent changes in water table, live loads applied to the structure, and loadings due to adjacent structures or construction. Granular soils are handled by empirical correlations to static or dynamic penetration field tests. MAGSETII takes into

account strain influence with depth in granular soils. It has two built-in methods to account for strain influence (Figure 1), or the user can enter a set of influence factors. Also, for granular soils, three methods are available for estimating settlements: Meyerhof's, D'Appolonia's, and Schmertmann's. The first two methods use data from a standard penetration test; Schmertmann's method uses data from a static cone penetrometer test (see Schuffman, Jubenville, and Partyka 1976).

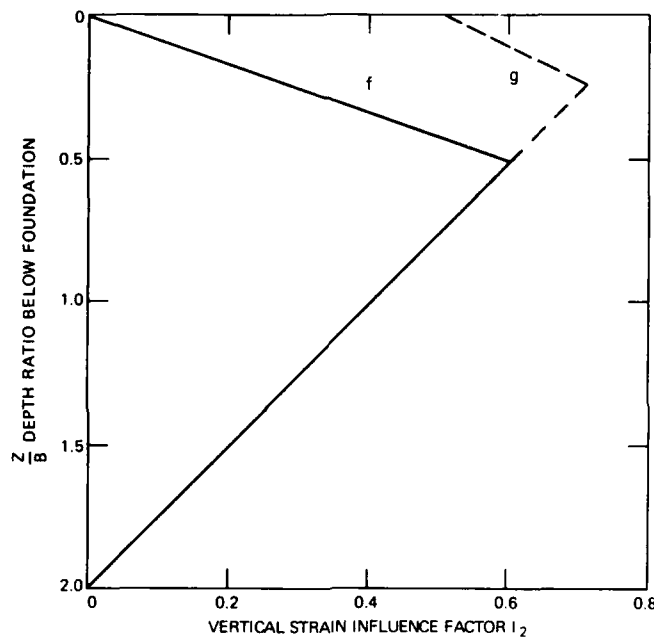


Figure 1. Strain influence in sands

7. A subroutine to compute rate of settlement has been added. These computations are based on Terzaghi's theory and methods described in EM 1110-2-1904. This addition gives the user the option to consider the effect of time-dependent loading on the rate of settlement, as outlined in EM 1110-2-1904.

Program FD31

8. Settlement and time-settlement relationships for compressible

materials are computed in FD31 based on Terzaghi's one-dimensional consolidation theory. The program is only valid for one-dimensional analysis. The differential equations derived from the theory are solved by finite difference methods of analysis. (See Olson.) FD31 provides the user with a very versatile tool to compute settlement and rate of settlement for cohesive soil. The program allows for a stratified soil profile, subject to time-dependent loadings; soils that are not linearly elastic, which may be subject to large and nonuniform strains, and whose coefficients of permeability and compressibility may vary with effective stresses; and stress conditions that are altered by a changing water table and settlement-dependent submergence of the soil.

9. FD31 is a specialized program. It is very sensitive to the data input, and the user must be careful in correctly modeling the in situ situation. Input data come from standard laboratory tests and field observations. The program does not take into account the influence of vertical stress distribution with depth.

Loads

10. Geometric configurations play an important part in the choice of program. Two basic types of loadings can be handled. These are: (a) concentrated loads and (b) uniformly distributed loads. If the width of the structure applying the load at the surface is relatively small in comparison to the depth of the compressible soil, the load can be considered to be concentrated. Loading conditions which fall under this category are: strip footings, spread footings, some raft foundations, and also embankments in which the base is relatively small in comparison to the compressible soil being considered. If the area being loaded is wide compared to the depth of the compressible soil, the load should be considered as uniformly distributed. Loading conditions which fall under this category are: fills, embankments, and large excavations.

11. For analysis of concentrated loads, MAGSETII is the primary program used. It can handle a multilayered soil profile of cohesive and/or granular material. It can account for preloadings and unloadings.

When estimating settlements for cohesive material under a concentrated loading, I0016 is used to calculate the vertical stress distribution beneath the point being investigated. The data from this program can be used directly in MAGSETII. To achieve the best accuracy, large layers of compressible material are subdivided into several smaller layers.

12. For analysis of large uniformly distributed loads on layers of compressible material, FD31 is used. In the case where a compressible soil and a granular soil are in the same profile, the settlement due to the granular material would be negligible in comparison with the settlement of the cohesive soil.

PART III: EXAMPLE PROBLEMS ILLUSTRATING INPUT/OUTPUT FOR
PROGRAMS I0016 AND MAGSETII

13. In this Part, two example problems are solved using programs I0016 and MAGSETII. Input/output for the two programs is also described. Results of problem 1 are compared with hand solutions. Problem 2 is taken from EM 1110-2-1904, and the results are compared with values from that source.

Example Problem 1

Program I0016

14. Organization of input. The input data are categorized into three groups: header lines, loading configuration data, and stress distribution data. The first of these groups consists of five lines of data describing the particular run. The second group describes the geometric configuration and loads applied by embankments and/or footings. The third group defines the type of analysis (Boussinesq or Westergaard) and the location and direction (whether distribution along a vertical or horizontal plane is desired). The amount of data required for the second and third data groups is dependent on the complexity of the problem and the output required.

15. Mode of input. Input to the program can be either from the terminal or from a data file. (Example problem 1 was solved using data input from the terminal; problem 2, which is discussed later in this Part, was solved by reading data already stored in a data file.) All input is in free field. Data items can be separated by a blank space or a comma. If information is being read from a data file, each line of data must be preceded by a line number. When operating from the terminal, the program can create files to save the input data and the output. Detailed input with definitions of input variables for program I0016 is shown in later paragraphs of this Part using problem 1 as an example.

16. Problem definition. Figure 2 shows a plan view of two rectangular footings loading the soil profile shown in Figure 3. The profile

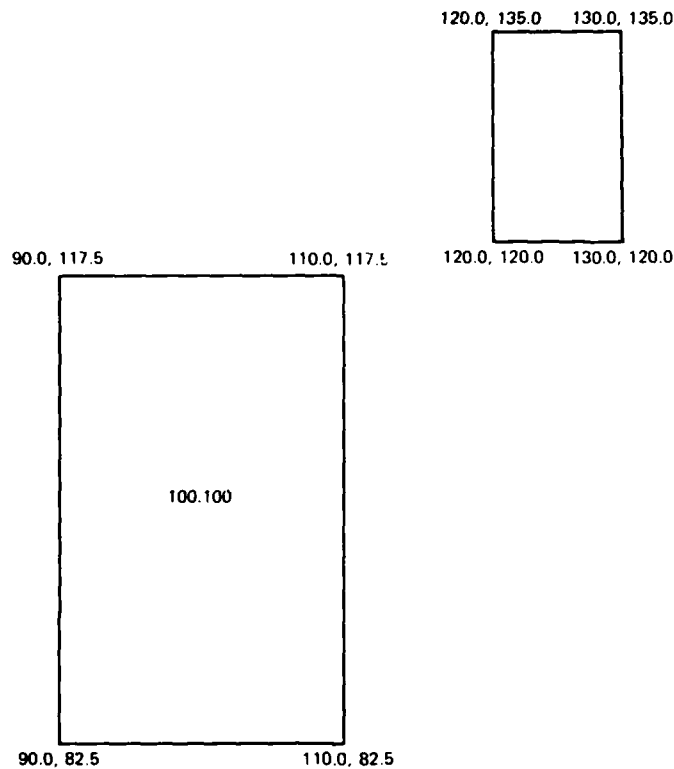


Figure 2. Plan view of footings

consists of 10 ft* of fill material and 15-, 6.5-, and 20.5-ft layers of clay material with a 25-ft layer of sand and gravel sandwiched between the last two clay layers. The water table is 25 ft below the surface.

17. The footings are placed after excavating 10 ft of material. Then 10 ft of new fill material is placed and compacted. As construction continues, the structure applies loads of 2.0 and 2.5 kips/ft², respectively, to the footings. At the end of construction, 0.5 kip/ft² is relieved from the footings. Table 1 shows this information and the times these events occur.

18. Figures 4-6 show void ratio versus effective stress curves

* A table of factors for converting inch-pound units of measurement to metric (SI) units is presented on page 3.

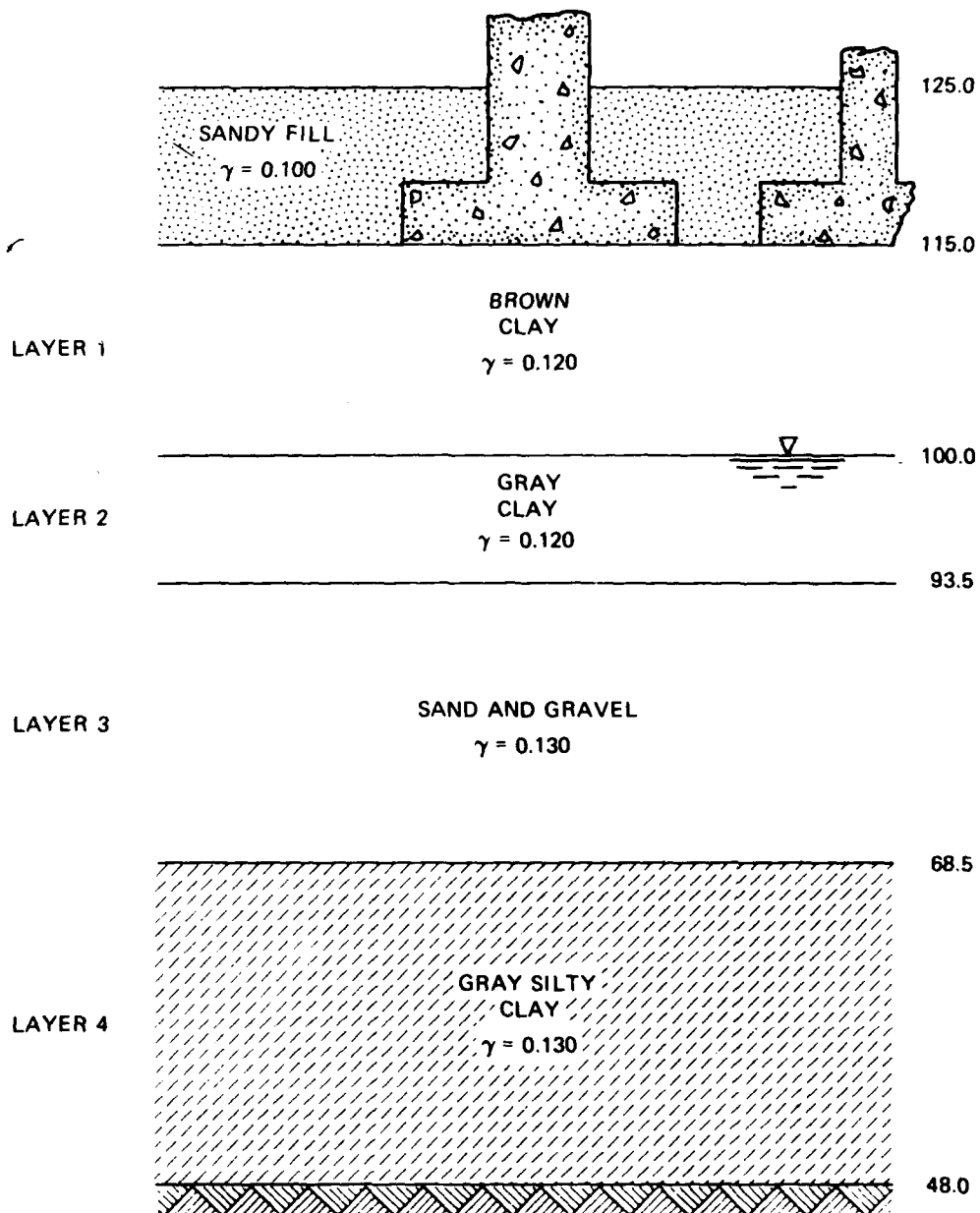


Figure 3. Soil profile for example problem 1

Table 1
Loading Conditions for Example Problem 1

<u>Load Increment</u>	<u>Load</u>	<u>Time Interval days</u>
1	10 ft of fill excavated	0 to 50
2	10 ft of new fill	50 to 75
3	2-kips/ft ² loading	75 to 200
4	2.5-kips/ft ² loading	200 to 300
5	0.5-kip/ft ² unloading	300 to 350

for the three clay layers in the soil profile. This information is given in tabular form in Table 2. Table 3 shows results from standard penetration tests for the sand layer.

19. For this example, the settlement is estimated under the center of the footing. Program I0016 is first used to calculate the vertical stress influence factors beneath the center of the footing for the cohesive layers. This will be done at the midheight of each layer.

20. Input. Data required for program I0016, arranged by groups, are shown below.

- a. Problem information. Five header lines are required at the beginning of the data entry. These lines may be used to describe pertinent information about the loading configuration to be analyzed. This information will be printed on the output sheet and will serve to identify the output. If fewer than five lines are used to identify the project, blank lines must be included to complete the required five lines. The information on the header lines may be up to 60 characters maximum. Data for example 1 for the five header lines are as follows:

```
=SAMPLE PROBLEM FOR SETTLEMENT
=OCT 1978
=VERTICAL STRESS DISTRIBUTION INFLUENCE FACTOR
=UNIT LOAD OF 1.0 WITHOUT FORCE UNIT
=TWO RECTANGULAR FOOTINGS
```

- b. Loading data. The type and number of lines in this group vary depending upon whether stresses are from footing loads, an embankment load, or both footing and embankment loads are being analyzed. The type of loading is specified by the variable KODE described below.

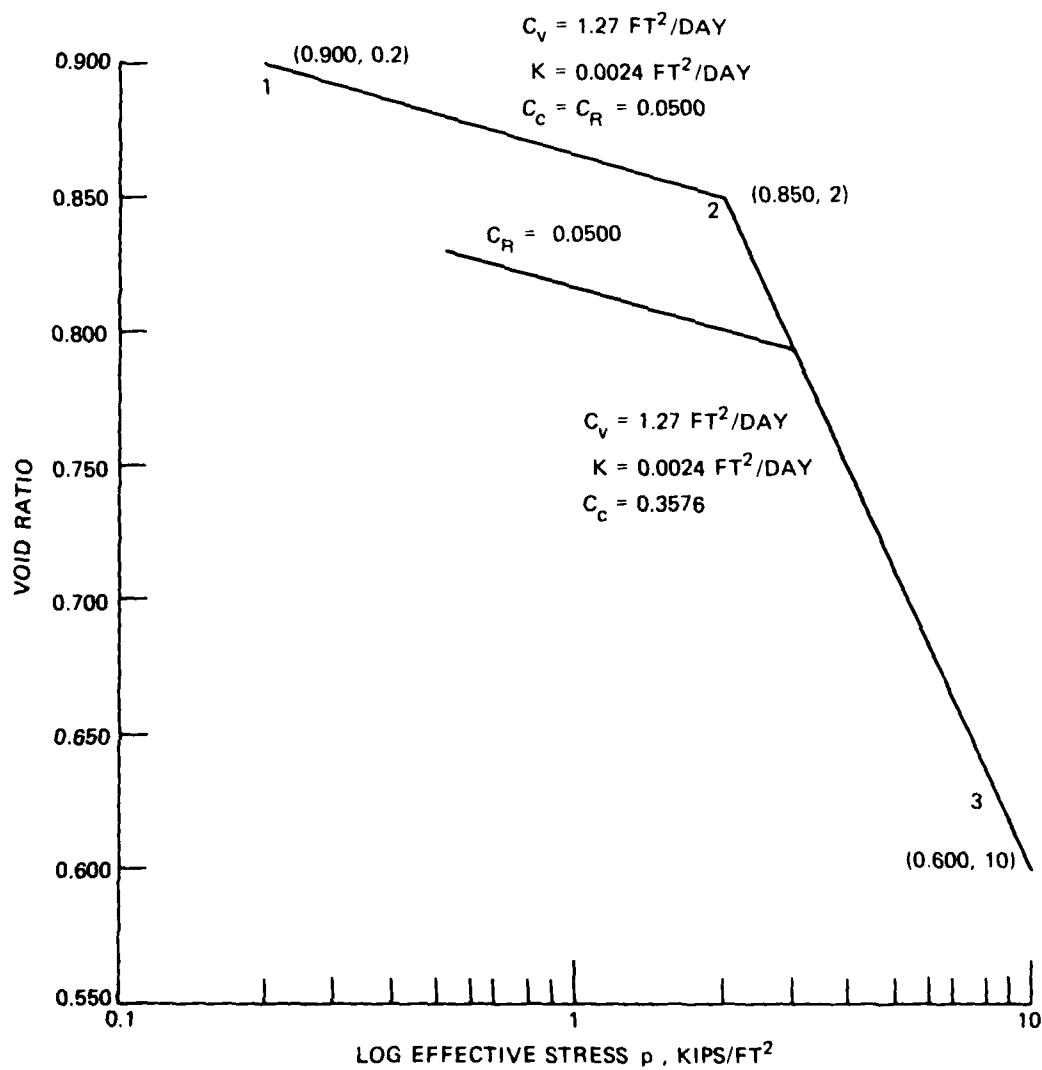


Figure 4. Void ratio versus effective stress curve for layer 1 in Figure 3

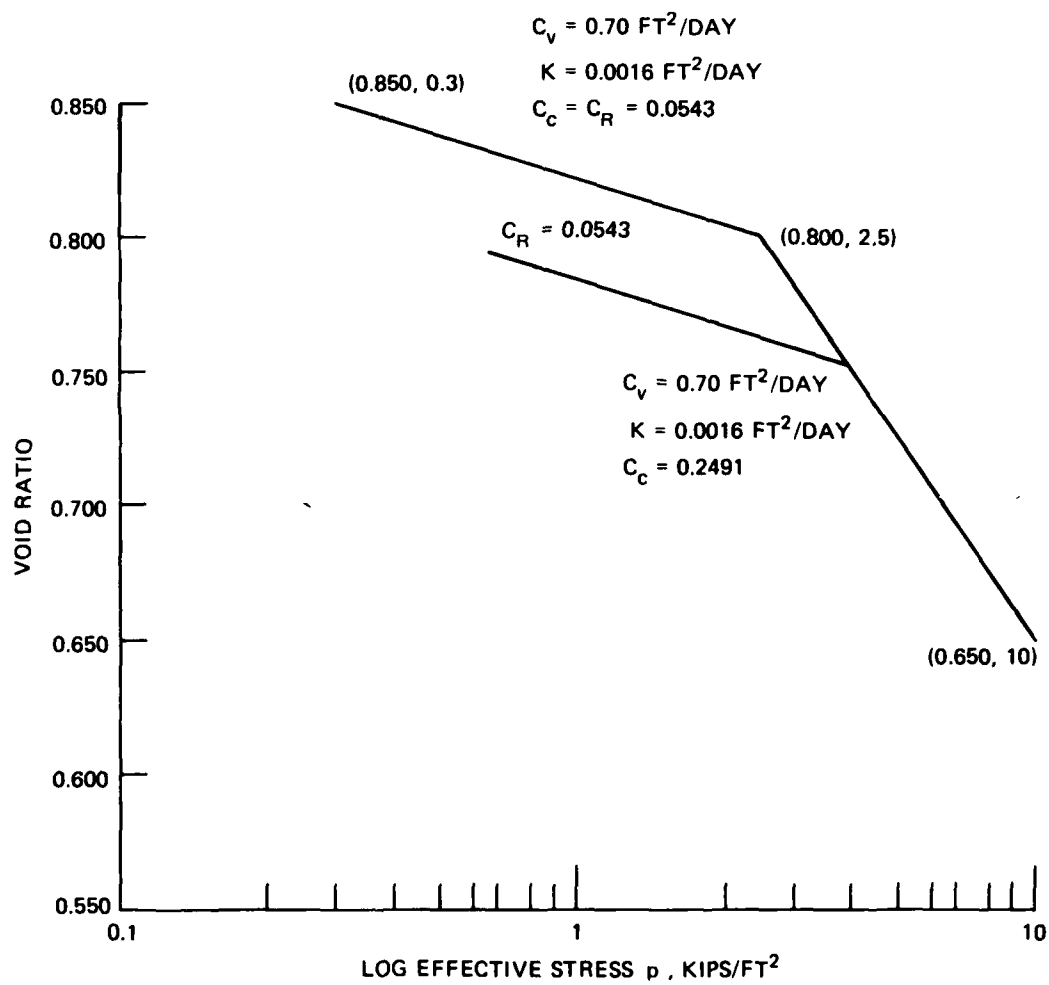


Figure 5. Void ratio versus effective stress curve for layer 2 in Figure 3

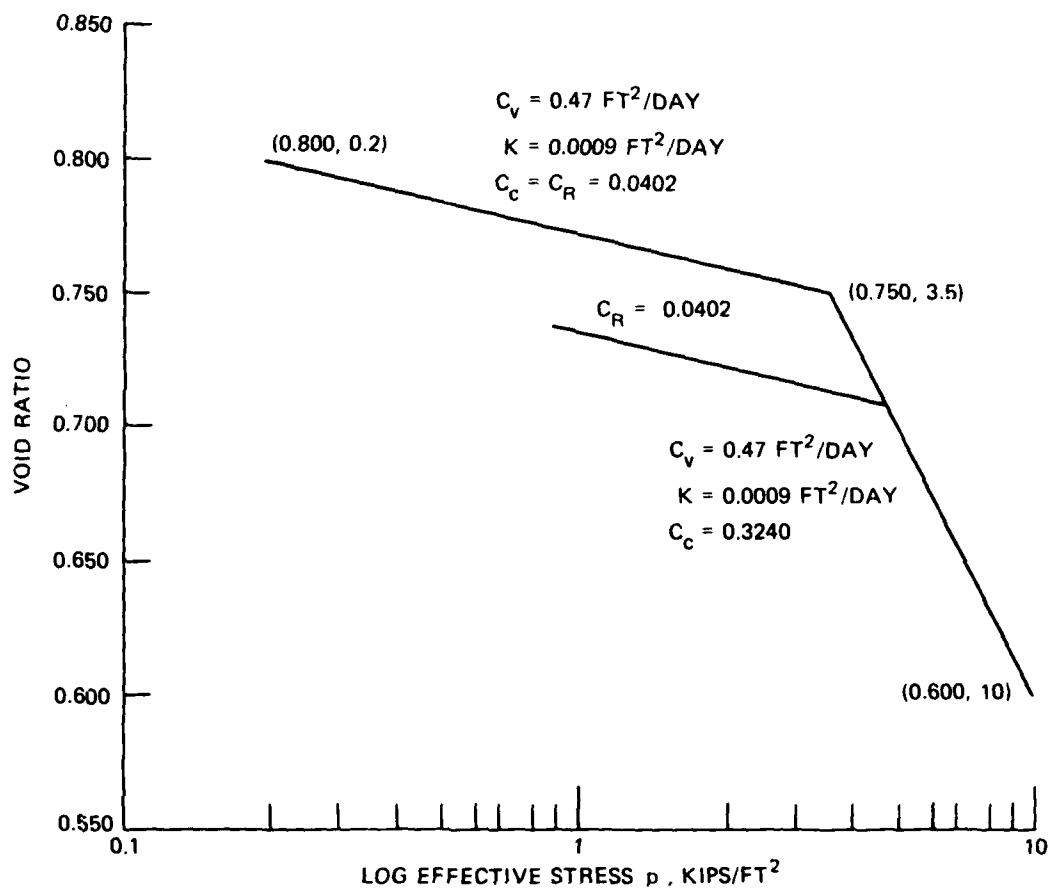


Figure 6. Void ratio versus effective stress curve for layer 4 in Figure 3

Table 2
Oedometer Test Results for Clay Layers in Example Problem 1

<u>Layer No.</u>	<u>Point No.</u>	<u>Void Ratio</u>	<u>Stress kips/ft²</u>	<u>C_c</u>	<u>C_R</u>	<u>C_v ft²/day</u>	<u>K ft²/day</u>
1	1	0.900	0.2	0.0500	0.0500	1.27	0.0024
1	2	0.850	2	0.3576	0.0500	1.27	0.0024
1	3	0.600	10				
2	1	0.850	0.3	0.0543	0.0543	0.70	0.0016
2	2	0.800	2.5	0.2491	0.0543	0.70	0.0016
2	3	0.650	10				
4	1	0.800	0.2	0.0402	0.0402	0.47	0.0009
4	2	0.750	3.5	0.3240	0.0402	0.47	0.0009
4	3	0.600	10				

Table 3
Results of Standard Penetration Test of Layer
No. 3 (Sand and Gravel)

<u>Depth ft</u>	<u>Corrected Blow Count</u>
93.5 to 85	32
85 to 80	35
80 to 75	20
75 to 70	30
70 to 68.5	40

* Average blow count = 33.3.

- (1) The first line in this group is the following:

KODE,NAREA

- (a) Item 1--KODE. KODE is a variable which indicates what type of loading configuration is to be used in the analysis. If KODE is input as 1, only uniform rectangular loads are to be used in the analysis. If KODE is input as 2, only an embankment load is to be used. If KODE is entered as 3, then both uniformly loaded rectangular areas and embankment loads are to be used in the analysis. (For input of embankment loads, see Appendix A.)
- (b) Item 2--NAREA. NAREA is the variable indicating the number of rectangular uniformly loaded areas (footings) to be entered. NAREA should be entered for KODE = 1 and KODE = 3 loading conditions but may be input as zero for KODE = 2 (embankment only) loading conditions. The maximum allowable value of NAREA is 100.

Input for example 1 for this data line is as follows:

KODE,NAREA
=1, 2

- (2) The next line(s) of the input data describes the location and loading for an individual rectangular loaded area(s). There will be one line of this information for each rectangular area in the loading configuration. When stresses from an embankment loading only are to be calculated (KODE = 2), this line should not be included in the input data. The following variables are required for this:

Q(I),ZLAY(I),XC(1,I),YC(1,I),XC(2-4,I),YC(2-4,I)

- (a) Item 1--Q(I). Q(I) is the magnitude of the uniform load on the Ith rectangular area. It is in units of LOAD/UNIT AREA. Any units for weight and length may be used as long as all input data are in the same units.
- (b) Item 2--ZLAY(I). Positive ZLAY(I) is the vertical distance from the base of the Ith footing to the vertical reference plane of the lowest point in the embankment. (No footings may be input lower than the lowest point in the embankment.)
- (c) Item 3--XC(1,I). XC(1,I) is the variable name of the X coordinate of the first corner of the Ith rectangular area. The dimensions of XC(1,I) may be in any units compatible with the remainder of the input data.

- (d) Item 4--YC(1,I). YC(1,I) is the variable name of the Y coordinate of the first corner of the Ith rectangular area.
- (e) Items 5-10--XC(2-4,I) and YC(2-4,I). These are the remaining three pairs of X and Y coordinates which define the corners of the Ith rectangular area. The sides of the area do not have to be parallel to the X and Y axes, but the corner points should be input in either clockwise or counterclockwise order around the perimeter of the rectangular area.

Without force units being used as the load, this would yield a factor which could be multiplied times any load to give the vertical stress at that point. Input data for example 1 for the two data lines (rectangular areas 1 and 2, respectively) are as follows:

Q(I),ZLAY(I),XC(1,I),YC(1,I),XC(2,I),YC(2,I),XC(3,I),
YC(3,I),XC(4,I),YC(4,I)

=1.0 0.0 90.0 82.5 90.0 117.5 110.0 117.5 110.0 82.5

Q(I),ZLAY(I),XC(1,I),YC(1,I),XC(2,I),YC(2,I),XC(3,I),
YC(3,I),XC(4,I),YC(4,I)

=1.0 0.0 120.0 120.0 120.0 135.0 130.0 135.0 130.0
120.0

- c. Stress distribution. This group of data defines the output required for the loading conditions described in subparagraph b above. The output may be in two forms, depending on the needs of the user. The first type of output consists of values of vertical stresses printed along a vertical line in the X-Y-Z plane. For this distribution, the values of X and Y will remain constant. Stress values will be calculated at prescribed increments between prescribed limits along the vertical line. The second type of output option consists of values of vertical stresses printed at increasing values of X along a prescribed line in the X-Y plane at a constant depth (Z is constant). The orientation of the line in the X-Y plane is defined by inputting a slope and an intercept. There is no limit as to the number of calculation points on a given distribution or on how many distributions may be run for a given loading configuration. The information for a single stress distribution is contained on two lines.

(1) The input variables on the first line are:

NDIST, NREST, AMU

- (a) Item 1--NDIST. NDIST is an option variable which defines whether stress distribution in a vertical

or horizontal plane is required. If NDIST is input as 1, a vertical plane distribution will be assumed; if NDIST is input as 2, a horizontal plane distribution is calculated. NDIST also serves to indicate when all the stress distributions for a given loading condition are completed. A value of NDIST equal to zero will cause new header cards and loading data to be read in. If no new loading configuration follows NDIST = 0, the program will exit.

- (b) Item 2--NWEST. NWEST is an option variable which determines whether the Westergaard or Boussinesq solution will be used to determine the vertical stresses. If NWEST = 0, the Westergaard solution will be used; if NWEST = 1, the Boussinesq solution will be calculated.
- (c) Item 3--AMU. AMU represents the value of Poisson's ratio to be used in the Westergaard solution. If a Boussinesq solution is to be used (NWEST = 1), AMU is input as zero.

Input for example 1 for this data group is as follows:

```
NDIST, NWEST, AMU
=2 1 0.0
```

- (2) The second line is used to define the stress distribution and should not be included if NDIST = 0. The card includes the following data:

```
AINTL, FINAL, DELTA, XP, YP, ZP, SLP, BLINE
```

Repeat this card for each distribution required (NDIST times).

- (a) Item 1--AINTL. AINTL is the starting point coordinate for either a vertical or a horizontal plane distribution. If a vertical plane distribution is required (NDIST = 1), the value of AINTL represents the initial (smallest) depth within the range of the distribution. For this case, AINTL must be positive. In the case of a horizontal plane distribution (NDIST = 2), AINTL represents the smallest (initial) X coordinate of the horizontal plane distribution. For a horizontal plane distribution, AINTL may be positive or negative.
- (b) Item 2--FINAL. FINAL is the ending point coordinate for either a vertical or a horizontal plane distribution. If a vertical plane distribution is required (NDIST = 1), the value of FINAL represents the final (largest) depth within the range

of the distribution. For this case, FINAL must be positive. In the case of a horizontal plane distribution (NDIST = 2), FINAL represents the largest X coordinate of the horizontal plane distribution. For this case, FINAL may be positive or negative.

- (c) Item 3--DELTA. DELTA is the distance between calculation points for both a horizontal and a vertical plane stress distribution. DELTA should always be positive.
- (d) Item 4--XP. XP is the X coordinate for the location of stress distribution on a vertical plane. If stress distribution on a horizontal plane is required, the value of XP may be input as zero.
- (e) Item 5--YP. YP is the Y coordinate for the location of a vertical plane. If stresses on a horizontal plane are required, the value of YP may be input as zero.
- (f) Item 6--ZP. ZP is the constant depth at which a horizontal plane is located. ZP should be positive and referenced to the lowest point in the embankment or footing configuration. If a vertical plane is being considered, the value of ZP may be input as zero.
- (g) Item 7--SLP. SLP is the slope in the X-Y plane of the line along which stress distribution is required. If a vertical plane is being considered, then the value of SLP may be input as zero.
- (h) Item 8--BLINE. BLINE is the Y intercept of the line in the X-Y plane along which a horizontal plane stress distribution is to be run. The value of BLINE may be input as zero if a vertical plane distribution is being run.

Input for example 1 for this data group is as follows:

```

AINTL,FINAL,DELTA,XP,YP,ZP,SLP,BLINE
=100.0 100.0 1.0 0.0 0.0 7.5 0.0 100.0

```

21. Input data for example 1 as stored in a data file are shown in Table 4.

22. Output. The output consists of vertical stress influence factors at the points requested. For example 1, this output, along with the input data, is shown in the conversational mode in Table 5. Table 6 shows a data file for the output data.

Table 4
Input Data File for Program I0016
(Example Problem 1)

CPI0016

15: 0:28 3/13/79

```

1000 SAMPLE PROBLEM FOR SETTLEMENT
1010 OCT 1978
1020 VERTICAL STRESS DISTRIBUTION INFLUENCE FACTOR
1030 UNIT LOAD OF 1.0 WITHOUT FORCE UNIT
1040 TWO RECTANGULAR FOOTINGS
1050 1 2
1060 1.0 0.0 90.0 82.5 90.0 117.5 110.0 117.5 110.0 82.5
1070 1.0 0.0 120.0 120.0 120.0 135.0 130.0 135.0 130.0 120.0
1080 2 1 0.0
1090 100.0 100.0 1.0 0.0 0.0 7.5 0.0 100.0
1100 2 1 0.0
1110 100.0 100.0 1.0 0.0 0.0 18.25 0.0 100.0
1120 2 1 0.0
1130 100.0 100.0 1.0 0.0 0.0 56.75 0.0 100.0
1140 0 0 0.0

```

Table 5
Input/Output in the Conversational Mode for Program 10016
 (Example Problem 1)

```

RUN WESLIB/CORPS/I0016.R
DO YOU WISH TO RUN PROGRAM FROM EXISTING DATA FILE?
=N
DO YOU WANT OUTPUT WRITTEN TO AN OUTPUT FILE?
=Y
INPUT 5 HEADER LINES
-SAMPLE PROBLEM FOR SETTLEMENT
-OCT 1978
-VERTICAL STRESS DISTRIBUTION INFLUENCE FACTOR
-UNIT LOAD OF 1.0 WITHOUT FORCE UNIT
-TWO RECTANGULAR FOOTINGS
CODE,NAREA
=1 2

Q(I),ZLAY(I),XC(1,I),YC(1,I),XC(2,I),YC(2,I),XC(3,I),YC(3,I),XC(4,I),YC
(4,I)
-1.0 0.0 90.0 82.5 90.0 117.5 110.0 117.5 110.0 82.5

Q(I),ZLAY(I),XC(1,I),YC(1,I),XC(2,I),YC(2,I),XC(3,I),YC(3,I),XC(4,I),YC
(4,I)
-1.0 0.0 120.0 120.0 120.0 135.0 130.0 135.0 130.0 120.0
NDIST, NUEST, AMU
-2 1 0 0

AINTL,FINAL,DELTA,XP,YP,ZP,SLP,BLINE
-100.0 100.0 1.0 0.0 0.0 7.5 0.0 100.0

SAMPLE PROBLEM FOR SETTLEMENT PACKAGE
OCT 1978
VERTICAL STRESS DISTRIBUTION INFLUENCE FACTOR
UNIT LOAD OF 1.0 WITHOUT FORCE UNITS
TWO RECTANGULAR FOOTINGS

BOUSSINESQ SOLUTION

HORIZONTAL STRESS DISTRIBUTION AT DEPTH(Z) = 7.50

Y-COORDINATE      X-COORDINATE      ELASTIC SOLUTION   NORMAL LOADING
-----          -----          -----          -----
100.00            100.00            0.882            0.882

NUMBER OF AREAS USED IN CALCULATION = 2

NOTE-ALL Z VALUES ARE REFERENCED TO THE LOWEST PART OF THE INPUT,
CONFIGURATION

NDIST, NUEST, AMU
-2 1 0 0

AINTL,FINAL,DELTA,XP,YP,ZP,SLP,BLINE
-100.0 100.0 1.0 0.0 0.0 18.25 0.0 100.0
  
```

(Continued)

Table 5 (Concluded)

SAMPLE PROBLEM FOR SETTLEMENT PACKAGE
OCT 1978
VERTICAL STRESS DISTRIBUTION INFLUENCE FACTOR
UNIT LOAD OF 1.0 WITHOUT FORCE UNITS
TWO RECTANGULAR FOOTINGS

BOUSSINESQ SOLUTION

HORIZONTAL STRESS DISTRIBUTION AT DEPTH(Z) = 18.25

Y-COORDINATE	X-COORDINATE	ELASTIC SOLUTION VERTICAL STRESS	NORMAL LOADING VERTICAL STRESS
100.00	100.00	0.509	0.509

NUMBER OF AREAS USED IN CALCULATION = 2

NOTE-ALL Z VALUES ARE REFERENCED TO THE LOWEST PART OF THE INPUT.
CONFIGURATION.

NDIST, NUEST, AMU
-2 1 0.0

AINTL, FINAL, DELTA, XP, YP, ZP, SLP, BLINE
-100.0 100.0 1.0 0.0 0.0 56.75 0.0 100.0

SAMPLE PROBLEM FOR SETTLEMENT PACKAGE
OCT 1978
VERTICAL STRESS DISTRIBUTION INFLUENCE FACTOR
UNIT LOAD OF 1.0 WITHOUT FORCE UNITS
TWO RECTANGULAR FOOTINGS

BOUSSINESQ SOLUTION

HORIZONTAL STRESS DISTRIBUTION AT DEPTH(Z) = 56.75

Y-COORDINATE	X-COORDINATE	ELASTIC SOLUTION VERTICAL STRESS	NORMAL LOADING VERTICAL STRESS
100.00	100.00	0.103	0.103

NUMBER OF AREAS USED IN CALCULATION = 2

NOTE-ALL Z VALUES ARE REFERENCED TO THE LOWEST PART OF THE INPUT.
CONFIGURATION.

NDIST, NUEST, AMU
-0 0 0.0

*

Table 6
Output Data File for Program 10016
(Example Problem 1)

CCI0016 14:59: 9 3/13/79

SAMPLE PROBLEM FOR SETTLEMENT PACKAGE
OCT 1978
VERTICAL STRESS DISTRIBUTION INFLUENCE FACTOR
UNIT LOAD OF 1.0 WITHOUT FORCE UNIT
TWO RECTANGULAR FOOTINGS

BOUSSINESQ SOLUTION

HORIZONTAL STRESS DISTRIBUTION AT DEPTH(Z) = 7.50

Y-COORDINATE	X-COORDINATE	ELASTIC SOLUTION VERTICAL STRESS	NORMAL LOADING VERTICAL STRESS
100.00	100.00	0.882	0.882

NUMBER OF AREAS USED IN CALCULATION = 2

NOTE-ALL Z VALUES ARE REFERENCED TO THE LOWEST PART OF THE INPUT,
CONFIGURATION.

SAMPLE PROBLEM FOR SETTLEMENT PACKAGE
OCT 1978
VERTICAL STRESS DISTRIBUTION INFLUENCE FACTOR
UNIT LOAD OF 1.0 WITHOUT FORCE UNIT
TWO RECTANGULAR FOOTINGS

BOUSSINESQ SOLUTION

HORIZONTAL STRESS DISTRIBUTION AT DEPTH(Z) = 18.25

Y-COORDINATE	X-COORDINATE	ELASTIC SOLUTION VERTICAL STRESS	NORMAL LOADING VERTICAL STRESS
100.00	100.00	0.509	0.509

NUMBER OF AREAS USED IN CALCULATION = 2

NOTE-ALL Z VALUES ARE REFERENCED TO THE LOWEST PART OF THE INPUT,
CONFIGURATION.

SAMPLE PROBLEM FOR SETTLEMENT PACKAGE
OCT 1978
VERTICAL STRESS DISTRIBUTION INFLUENCE FACTOR
UNIT LOAD OF 1.0 WITHOUT FORCE UNIT
TWO RECTANGULAR FOOTINGS

BOUSSINESQ SOLUTION

HORIZONTAL STRESS DISTRIBUTION AT DEPTH(Z) = 56.75

Y-COORDINATE	X-COORDINATE	ELASTIC SOLUTION VERTICAL STRESS	NORMAL LOADING VERTICAL STRESS
100.00	100.00	0.103	0.103

NUMBER OF AREAS USED IN CALCULATION = 2

NOTE-ALL Z VALUES ARE REFERENCED TO THE LOWEST PART OF THE INPUT,
CONFIGURATION.

Program MAGSETII

23. Organization of input. Input for MAGSETII is broken down into two basic areas: problem control and data entry. The first governs the execution of the program and allows the user to describe what data and what form of data are to be entered. One more option to the program has been added to perform a rate of settlement analysis.

24. Mode of input. Input to the program can be either from the terminal or from a data file. All input is in free field. Data items can be separated by a blank or a comma. If the program is being run from a data file, lines of the data file must be preceded by a line number. When the program is run from a terminal, it can create files to save the input data and output from the run.

25. After receiving the output from I0016, MAGSETII can be used to calculate the settlement and the rate of consolidation. Input for this program is shown in Tables 7 and 8.

26. Problem control input. The first line in this section gives the information on one particular run and controls whether or not more than one problem is going to be run. The next line is a title description of the particular problem.

27. Data input. The first line in this section gives the problem options for the output and data input control. There are eight of these options:

- a. Unit indicator. This specifies whether the units are to be shown in the output.
- b. Effective stress indicator. This indicates whether the effective stress is to be calculated at midpoints or input at each soil layer or to combine the calculated and the input effective stress.
- c. Effective stress history specifications. This indicates, if clay layers are present, whether the effective stress history is to be input for each clay layer or one is to be used for all clay layers or the vertical stress distribution function is to be multiplied time one effective stress history for all clay layers.
- d. Deformation curve type. This indicates, if clay layers are present, whether the deformation curve is a strain or a void ratio versus effective stress relationship.

Table 7

Input in the Conversational Mode for Program MAGSETII

(Example Problem 1)

RUN

INPUT NAME OF DATA FILE. HIT A CARRIAGE RETURN
IF DATA IS TO BE READ FROM THE TERMINAL.

INPUT A FILE NAME FOR DATA IN 8 CHARACTERS OR LESS.
HIT A CARRIAGE RETURN IF YOU DO NOT WANT TO SAVE THIS FILE
-REEDIN

INPUT A FILE NAME FOR OUTPUT IN 8 CHARACTERS OR LESS
HIT A CARRIAGE RETURN IF DATA IS TO BE PRINTED ON TERMINAL
-REEDOUT

INPUT PROBLEM CONTROL INFORMATION

NPROB - PROBLEM NUMBER

NLAYER - NUMBER OF SOIL LAYERS IN PROFILE. MAX=15

NLAST - 0 IF CURRENT PROBLEM ISN'T LAST ONE

1 CURRENT PROBLEM IS LAST ONE IN DATA SET

-1.5.1

INPUT PROBLEM OPTIONS

IOPT(1) - UNITS INDICATOR

1 - UNITS TO BE PRINTED IN OUTPUT

2 - UNITS WILL NOT BE PRINTED

IOPT(2) - INSITU EFFECTIVE STRESS INDICATOR

1 - IES CALCULATED AT MIDPOINTS

2 - IES INPUT AT EACH LAYER

3 - IES INPUT AT EACH LAYER AND ADDED TO CALC. IES

IOPT(3) - EFFECTIVE STRESS HISTORY SPECIFICATIONS

0 - NO CLAY LAYERS

1 - ESH INPUT FOR EACH CLAY LAYER

2 - ONE ESH INPUT AND USED FOR ALL LAYERS

3 - ONE ESH INPUT AND USED FOR ALL CLAY LAYERS

STRESS DISTRIBUTION FUNCTION WILL BE INPUT

IOPT(4) - DEFORMATION CURVE TYPE

0 - NO CLAY LAYERS

1 - STRAIN-EFFECTIVE STRESS CURVES

2 - VOID RATIO-EFFECTIVE STRESS CURVES

IOPT(5) - DEFORMATION CURVE SPECIFICATION

0 - NO CLAY LAYERS

1 - DC INPUT USING COORD. PTS. OF VOID RATIO OR
STRAIN VS. EFFECTIVE STRESS

2 - DC INPUT USING SLOPES, EFF. STRESS VALUES AND A
REFERENCE COORDINATE

IOPT(6) - SAND SETTLEMENT METHOD INDICATOR

0 - NO SAND LAYERS

1 - MEYERHOFF'S METHOD

2 - D'APPOLONIA'S METHOD

3 - ALL THREE METHODS

IOPT(7) - VERTICAL STRAIN INFLUENCE FUNCTION

0 - NO SAND LAYERS

1 - CURVE Q

2 - CURVE F

3 - VERTICAL STRAIN INFLUENCE FUNCTION WILL BE INPUT

IOPT(8) - DATUM CONVERSION OPTION

(Continued)

Table 7 (Continued)

INPUT TITLE
TITLE - DESCRIPTION OF PROBLEM IN 66 CHARACTERS OR LESS
• SAMPLE PROBLEM FOR SETTLEMENT PACKAGE

1 - DEPTHS OR ELEVATIONS UI
LL NOT BE CONVERTED
2 - DEPTHS OR ELEVATIONS UI
LL BE CONVERTED
-1.1.3.2.1.1.1.2

INPUT UNITS
IUNIT(1) - LENGTH UNITS IN COLUMNS 1-16
IUNIT(2) - FORCE UNITS IN COLUMNS 17-32
• FEET KIPS

INPUT GROUND WATER DATA
QU - TNIT WEIGHT OF WATER
QUELEV - DEPTH OR ELEV. OF GROUND WATER SURFACE
- .0624.100.0

INPUT LAYER INTERFACE INFORMATION
L - LAYER INTERFACE NUMBER
DEPTH(L) - DEPTH OR ELEV. TO TOP OF LAYER

LAYER NUMBER 1
-1.125.0

LAYER NUMBER 2
-2.115.0

LAYER NUMBER 3
-3.100.0

LAYER NUMBER 4
-4.03.5

LAYER NUMBER 5
-5.68.5

LAYER NUMBER 6
-6.48.0

(Continued)

Table 7 (Continued)

INPUT SOIL PROPERTIES
 L - LAYER NUMBER
 NTYPE(L) - SOIL TYPE
 1 - CLAY
 2 - SAND
 3 - INCOMPRESSIBLE
 WGT(L) - TOTAL UNIT WEIGHT OF SOIL

 LAYER NUMBER 1
 -1.3..100

 LAYER NUMBER 2
 -2.1..120

 LAYER NUMBER 3
 -3.1..120

 LAYER NUMBER 4
 -4.2..130

 LAYER NUMBER 5
 -5.1..130

 INPUT DATUM CONVERSION INFORMATION
 DATUM - DATUM ELEVATION
 DIFELU - DIFF. IN ELEV. BETWEEN DATUM ELEV & TOP OF 1ST LAYER
 -125.0.0.0

 INPUT EFFECTIVE STRESS INCREMENTS
 SIG1(NS) - THE (NSTH) ESI
 LS - LAST INCREMENT INDICATOR
 0 - IF MORE ESI'S TO BE INPUT
 1 - IF LAST ESI

 STRESS INCREMENT NUMBER 1
 --1.0.0

 STRESS INCREMENT NUMBER 2
 -1.3.0

 STRESS INCREMENT NUMBER 3
 -2.0.0

 STRESS INCREMENT NUMBER 4
 -2.5.0

 STRESS INCREMENT NUMBER 5
 --0.5.1

 INPUT STRESS DISTRIBUTION FUNCTION
 L - CLAY LAYER NUMBER
 F(L) - VALUE OF SDF

 LAYER NUMBER 2
 -2..88

 LAYER NUMBER 3
 -3..51

 LAYER NUMBER 5
 -5..103

(Continued)

Table 7 (Continued)

```

INPUT DEFORMATION CURVE COORDINATE POINTS
  ILAYER - CLAY LAYER NUMBER
  LINEPT(I,IPT) - FIRST POINT ON DC = 1
  E(I,IPT) - VOID RATIO OR STRAIN COORD AT 1ST PT ON DC
  SIGMAP(I,IPT) - EFFECTIVE STRESS COORD AT 1ST PT ON DC
-2.1..90..80

INPUT DEFORMATION CURVE - SUBSEQUENT COORD PTS
  ILAYER - CLAY LAYER NUMBER
  LINEPT(I,IPT) - COORD PT ON DC
  E(I,IPT) - VOID RATIO OR STRAIN AT COORD PT
  SIGMAP(I,IPT) - EFFECTIVE STRESS AT COORD PT
  ER(I,IPT-1) - VOID RATIO OR STRAIN COORD TO BE USED TO
                  CALCULATE EXPANSION SLOPE
  SIGR(I,IPT-1) - EFFECTIVE STRESS TO BE USED TO CALC
                  EXPANSION SLOPE
  LP - LAST POINT INDICATOR
      0 - NOT LAST POINT
      1 - LAST POINT
INCREMENT 2
-2.2..85.2.0..90..20.0
INCREMENT 3
-2.3..60.10.0..85.2.0.1

INPUT DEFORMATION CURVE COORDINATE POINTS
  ILAYER - CLAY LAYER NUMBER
  LINEPT(I,IPT) - FIRST POINT ON DC = 1
  E(I,IPT) - VOID RATIO OR STRAIN COORD AT 1ST PT ON DC
  SIGMAP(I,IPT) - EFFECTIVE STRESS COORD AT 1ST PT ON DC
-3.1..85..30

INPUT DEFORMATION CURVE - SUBSEQUENT COORD PTS
  ILAYER - CLAY LAYER NUMBER
  LINEPT(I,IPT) - COORD PT ON DC
  E(I,IPT) - VOID RATIO OR STRAIN AT COORD PT
  SIGMAP(I,IPT) - EFFECTIVE STRESS AT COORD PT
  ER(I,IPT-1) - VOID RATIO OR STRAIN COORD TO BE USED TO
                  CALCULATE EXPANSION SLOPE
  SIGR(I,IPT-1) - EFFECTIVE STRESS TO BE USED TO CALC
                  EXPANSION SLOPE
  LP - LAST POINT INDICATOR
      0 - NOT LAST POINT
      1 - LAST POINT
INCREMENT 2
-3.2..80.2.50..85..30.0
INCREMENT 3
-3.3..65.10.0..80.2.5.1

```

(Continued)

Table 7 (Continued)

```

INPUT DEFORMATION CURVE COORDINATE POINTS
  ILAYER - CLAY LAYER NUMBER
  LINEPT(I,IPT) - FIRST POINT ON DC = 1
  E(I,IPT) - VOID RATIO OR STRAIN COORD AT 1ST PT ON DC
  SIGMAP(I,IPT) - EFFECTIVE STRESS COORD AT 1ST PT ON DC
-5.1. 80. 80

INPUT DEFORMATION CURVE - SUBSEQUENT COORD PTS
  ILAYER - CLAY LAYER NUMBER
  LINEPT(I,IPT) - COORD PT ON DC
  E(I,IPT) - VOID RATIO OR STRAIN AT COORD PT
  SIGMAP(I,IPT) - EFFECTIVE STRESS AT COORD PT
  ER(I,IPT-1) - VOID RATIO OR STRAIN COORD TO BE USED TO
    CALCULATE EXPANSION SLOPE
  SIGR(I,IPT-1) - EFFECTIVE STRESS TO BE USED TO CALC
    EXPANSION SLOPE
  LP - LAST POINT INDICATOR
    0 - NOT LAST POINT
    1 - LAST POINT
INCREMENT 2
-5.2. 75.3.50. 80. 20.0
INCREMENT 3
-5.3. 60.10.0. 75.3.50.1

INPUT PENETRATION RESISTANCE
  L - SAND LAYER NUMBER
  BLOW(L) - STANDARD PENETRATION TEST BLOWCOUNT IN
    BLOWS PER FOOT
    0 - IF IOPT(6)=3
  QC(L) - STATIC CONE PENETRATION RESISTANCE
    0 - IF IOPT(6)=1 OR 2

SAND LAYER NUMBER 4
-4.33.3.0.0

INPUT FOOTING DATA
  FP - AVG FOOTING PRESSURE
  FB - FOOTING WIDTH
  FDEPTH - DEPTH OR ELEV OF FOOTING
-5.0.20.0.115.0

INPUT MEYERHOFF'S CONVERSION FACTORS
  CONUFT - LENGTH CONVERSION FACTOR
  CONUTN - FORCE CONVERSION FACTOR
-1.0.0.5

```

(Continued)

Table 7 (Concluded)

INPUT PROGRAM CONTROL
 NHIST - 0 NO RATE OF CONSOLIDATION IN OUTPUT
 1 HISTORY OF RATE OF CONSOLIDATION IN OUTPUT
 2 SETTLEMENTS AND DEGREE OF CONSOLIDATION AT
 THE END OF LOADING INCREMENTS AND SPECIFIC
 TIMES AFTER LOADING

-2

INPUT COEFFICIENT OF CONSOLIDATION
 L - LAYER NUMBER
 CU - COEFFICIENT OF CONSOLIDATION(SQ.FT./DAY)
 NTOP - 0 IF TOP IS FREELY DRAINED
 1 IF TOP IS NOT FREELY DRAINED
 NBOT - 0 IF BOTTOM IS FREELY DRAINED
 1 IF BOTTOM IS NOT FREELY DRAINED

CU FOR LAYER NUMBER 2
 -2.1.27.0.1

CU FOR LAYER NUMBER 3
 -3.70.1.0

CU FOR LAYER NUMBER 5
 -5.47.0.0

INPUT TIMES FOR LOADING INCREMENTS
 T - THE TIME(IN DAYS) FROM THE BEGINNING OF
 CONSTRUCTION TO THE END OF THE LOAD INCREMENT
 (LOAD INCREMENT-STRESS INCREMENT IN OPTION 3)
 MAX. NUMBER = 10

LOAD INCREMENT NO. 1
 -50.0

LOAD INCREMENT NO. 2
 -75.0

LOAD INCREMENT NO. 3
 -200.0

LOAD INCREMENT NO. 4
 -300.0

LOAD INCREMENT NO. 5
 -350.0

INPUT TIMES FOR AFTER CONSTRUCTION
 T - NUMBER OF DAYS FROM THE BEGINNING OF CONSTRUCTION
 TO A TIME AFTER THE FINAL LOADING
 ENTER 0.0 FOR LAST ONE.(MAX. NUMBER=10)

A TIME AFTER CONSTRUCTION 1
 -400.0

A TIME AFTER CONSTRUCTION 2
 -500.0

A TIME AFTER CONSTRUCTION 3
 -600.0

A TIME AFTER CONSTRUCTION 4
 -1000.0

A TIME AFTER CONSTRUCTION 5
 -0.0

3

Table 8
Input Data File for Program MAGSET11
 (Example Problem 1)

REEDIN	8.43.14 3/ 8/79									
10000	1	5	1							
10010	SAMPLE PROBLEM FOR SETTLEMENT PACKAGE									
10020	1	1	3	2	1	1	1	2		
10030	FEET			KIPS						
10040	0	0624	100	0000						
10050	1	125	0000							
10060	2	115	0000							
10070	3	100	0000							
10080	4	93	5000							
10090	5	68	5000							
10100	6	48	0000							
10110	1	3	0	1000						
10120	2	1	0	1200						
10130	3	1	0	1200						
10140	4	2	0	1300						
10150	5	1	0	1300						
10160	125	0000	0							
10170	-1	0000	0							
10180	1	3000	0							
10190	2	0000	0							
10200	2	5000	0							
10210	-0	5000	1							
10220	2	0	8800							
10230	3	0	5100							
10240	5	0	1030							
10250	2	1	0	9000	0	2000				
10260	2	2	0	8500	2	0000	0	9000	0	2000
10270	2	3	0	6000	10	0000	0	8500	2	0000
10280	3	1	0	8500	0	3000				
10290	3	2	0	8000	2	5000	0	8500	0	3000
10300	3	3	0	6500	10	0000	0	8000	2	5000
10310	5	1	0	8000	0	2000				
10320	5	2	0	7500	3	5000	0	8000	0	2000
10330	5	3	0	6000	10	0000	0	7500	3	5000
10340	4	33	3000	0						
10350	5	0000	20	0000	115	0000				
10360	1	0000	0	5000						
10380	2									
10390	2	1	2700	0	1					
10400	3	0	7000	1	0					
10410	5	0	4700	0	0					
10420		50	00							
10421		75	00							
10422		200	00							
10423		300	00							
10424		350	00							
10425		400	00							
10426		500	00							
10427		600	00							
10428		1000	0							
10429		0								

- e. Deformation curve specifications. This indicates if the deformation curves are to be input by coordinate points upon a void ratio or strain versus effective stress curve with slopes to be calculated between points entered or by entering the slopes and reference points on the curve.
- f. Sand settlement methods indicator. If a sand layer is present, it indicates the method of analysis that needs to be employed by the program for estimating the settlement of the sand layers.
- g. Vertical strain influence functions. If sand layers are present, it indicates whether one of the built-in strain influence curves is to be used or a function is to be entered by the user.
- h. Datum conversion option. This is used to select whether the depth or elevation is to be converted for the output.

28. Output. The output from a successfully executed MAGSETII problem is printed under several headings. The information under these headings may vary slightly, depending on the problem options chosen. A brief description of the information printed under these headings is given below.

- a. Problem specifications. Printed under this heading are the program header, title, and units.
- b. Soil profile description. The soil profile description prints the layer number, layer type, interface depths or elevations, datum elevations, layer thickness, and the total unit weights of the soils. Also under this heading are the groundwater information, the unit weight of water, the depth or elevation of the groundwater table, and the datum elevation of the groundwater.
- c. In situ effective stress. Under this heading are the input and in situ effective stresses in each layer and the in situ effective stress used by the program.
- d. Clay settlement data. This section contains the effective stress history and deformation curve data. The input effective stress increments and the effective stress history are printed. The input data used to specify the deformation curves are printed along with any data calculated that define the deformation curve. If void ratio versus effective stress curves are input, the compression and expansion indexes C_c and C_e are output along with strain compression and strain expansion indexes C_{cc} and C_{ee} . If strain versus effective stress curves are input, only the strain compression and strain expansion slopes are output.

- e. Sand settlement data. This section contains the data used in the sand settlement calculations. It includes calculation methods, foundation data, the penetration resistance for each sand layer, and the strain influence function used. It also includes information which is method-dependent, such as D'Appolonia's parameters and Meyerhof's conversion factors.
- f. Clay settlement contributions. The clay settlement contributions contain the settlement in each layer due to each effective stress increment, the total clay settlement in each layer, the settlement in the clay profile due to each effective stress increment, and the total clay settlement.
- g. Clay compressibilities. The coefficient of constrained compressibility m_v in each layer for each effective stress increment is printed. The column header E1 defines the void ratio or strain value at the beginning of the effective stress increment depending on the form of the deformation curves input. The column header E2 defines the void ratio or strain at the end of the effective stress increment. The column header DELTA E is the value of E2 minus E1.
- h. Sand settlements. The settlements in each sand layer are printed under the method of analysis. The total sand settlement over the sand profile is printed along with the total clay settlement and total profile settlement.
- i. Error messages. Various checks are made on the input data. If any of these checks fail, an error message is printed and the program terminates execution. The error messages have been worded to be reasonably self-explanatory. If confusion results, however, refer to Chapter 1 of Schiffman, Jubenville, and Partyka (1976) under the appropriate sections. Table 9 presents the output of MAGSETII for example problem 1.
- j. Degree of consolidation. The time (in days), time factor (TV), and the degree of consolidation are output for each soil layer at each 10 percent increment or at a specific time.

Comparison with hand calculations

29. Example problem 1 was worked by hand using conventional methods. Results from program I0016, using a Boussinesq solution, were compared to answers from an influence chart for vertical pressure for Boussinesq's equation, commonly known as Newmark's chart

Table 9
Output Data for Program MAGSETII
(Example Problem 1)

```

REEDOUT                                15:26:15    2/13/79

1
*****
*
*      MAGSET-II
*
* MAGNITUDE OF SETTLEMENT OF
* A MULTI-LAYERED SOIL SYSTEM
*
*****

*****
* SPECIFICATIONS FOR
* PROBLEM NO. 1
*
*****

***** TITLE *****
SAMPLE PROBLEM FOR SETTLEMENT PACKAGE
***** UNITS *****
      LENGTH      FORCE
      FEET        KIPS

*****
* SOIL PROFILE
* DESCRIPTION
*****

      DATUM ELEVATION      = 125.00
      DIFFERENCE IN ELEVATION = 0.
      INTERFACE DATUM
      ELEVATION ELEVATIONS THICKNESS UNIT
      NUMBER TYPE          WEIGHT

      1 INCOMP          125.00 125.00 10.00 0.1000
      2 CLAY            115.00 115.00 15.00 0.1200
      3 CLAY            100.00 100.00 6.50 0.1200
      4 SAND             93.50  93.50 25.00 0.1300
      5 CLAY             68.50  68.50 20.50 0.1300
      48.00  48.00

      UNIT WEIGHT      GROUND WATER      GROUND WATER
      OF WATER         LEVEL             DATUM ELEVATION
      0.0624          100.00            100.00

*****
* INSITU EFFECTIVE STRESS
*****

      LAYER      INPUT      CALCULATED      INSITU
      NUMBER     VALUE      VALUE             STRESS
      1          -          0.5000          0.5000
      2          -          1.9000          1.9000
      3          -          2.9872          2.9872
      4          -          4.0184          4.0184
      5          -          5.5573          5.5573

*****
* CLAY SETTLEMENT DATA
*****

EFFECTIVE STRESS INCREMENTS INPUT BY
*
***** STRESS INCREMENTS FOR STRATUM *****
      POINT NUMBER      STRESS INCREMENT
      1                  -1.0000
      2                   1.3000
      3                   2.0000
      4                   2.5000
      5                  -0.5000

```

(Continued)

Table 9 (Continued)

REEDOUT

15:26:15 2/13/79

***** STRESS DISTRIBUTION FUNCTION *****

LAYER NUMBER	VALUE
2	0.8800
3	0.5100
5	0.1030

***** EFFECTIVE STRESS HISTORY *****

LAYER NO.	PT. NO.	STRESS INCREMENT	STRESS VALUES
2	1	-0.8800	1.0200
2	2	1.1440	2.1640
2	3	1.7600	3.9240
2	4	2.2000	6.1240
2	5	-0.4400	5.6840
3	1	-0.5100	2.4772
3	2	0.6630	3.1402
3	3	1.0200	4.1602
3	4	1.2750	5.4352
3	5	-0.2550	5.1802
5	1	-0.1030	5.4543
5	2	0.1339	5.5882
5	3	0.2060	5.7942
5	4	0.2575	6.0517
5	5	-0.0515	6.0002

DEFORMATION CURVES INPUT BY

COORDINATE POINTS

***** COORDINATES OF POINTS ON THE DEFORMATION CURVES *****

LAYER NUMBER	POINT NUMBER	VOID RATIO	STRESS	REBOUND VOID RATIO	REBOUND STRESS
2	1	0.9000	0.2000		
2	2	0.8500	2.0000	0.9000	0.2000
2	3	0.6000	10.0000	0.8500	2.0000
3	1	0.8500	0.3000		
3	2	0.8000	2.5000	0.8500	0.3000
3	3	0.6500	10.0000	0.8000	2.5000
5	1	0.8000	0.2000		
5	2	0.7500	3.5000	0.8000	0.2000
5	3	0.6000	10.0000	0.7500	3.5000

***** SLOPES ON THE DEFORMATION CURVES *****

LAYER NUMBER	LINE NUMBER	CC	CE	CC (STRAIN)	CE (STRAIN)
2	1	0.0500	0.0500	0.0263	0.0263
2	2	0.3577	0.3577	0.1933	0.1933
3	1	0.0543	0.0543	0.0294	0.0294
3	2	0.2491	0.2491	0.1384	0.1384
5	1	0.0402	0.0402	0.0223	0.0223
5	2	0.3290	0.3290	0.1800	0.1800

(Continued)

Table 9 (Continued)

 SAND SETTLEMENT DATA

***** FOUNDATION DATA *****
 RECORDOUT 15:26:15 2/13/79

FOOTING WIDTH	FOOTING PRESSURE	FOOTING ELEVATION
20.0000	5.0000	115.0000

***** SAND SETTLEMENT METHODS *****
 MEYERHOF

LAYER NUMBER	SPT BLOWCOUNT	STATIC CONE PENETRATION RESISTANCE
4	33.30	-

***** MEYERHOF UNITS CONVERSION FACTORS *****

ONE LENGTH UNIT EQUALS	1.0000	FEET
ONE FORCE UNIT EQUALS	0.5000	TONS

***** STRAIN INFLUENCE FUNCTION *****
 THE STRAIN INFLUENCE FUNCTION USED IS CURVE G

 CLAY SETTLEMENT CONTRIBUTIONS

LAYER NUMBER	STRESS INTERVAL	INCREMENTAL SETTLEMENT
2	1 TO 2	-0.10946
2	2 TO 3	0.21768
2	3 TO 4	0.74912
2	4 TO 5	0.56025
2	5 TO 6	-0.00385
2	LAYER HISTORY	1.32375
3	1 TO 2	-0.07111
3	2 TO 3	0.09084
3	3 TO 4	0.11109
3	4 TO 5	0.10559
3	5 TO 6	-0.01898
3	LAYER HISTORY	0.21743
5	1 TO 2	-0.03254
5	2 TO 3	0.04219
5	3 TO 4	0.06297
5	4 TO 5	0.07563
5	5 TO 6	-0.01487
5	LAYER HISTORY	0.13338

STRESS INTERVAL	SETTLEMENT OVER PROFILE
1 TO 2	-0.21311
2 TO 3	0.35070
3 TO 4	0.92318
4 TO 5	0.74147
5 TO 6	-0.12769
TOTAL CLAY SETTLEMENT	1.87456

(Continued)

Table 9 (Continued)

CLAY COMPRESSIBILITIES							

LAYER	STRESS		NU	DELTA E	E1	E2	
REEDOUT					15126115	2/13/79	
2	1	TO 2	0.00029	-0.01351	0.85111	0.86462	
2	2	TO 3	0.01259	0.02686	0.86462	0.83776	
2	3	TO 4	0.02858	0.0245	0.83776	0.74531	
2	4	TO 5	0.01861	0.06914	0.74531	0.67617	
2	5	TO 6	0.01570	-0.01158	0.67617	0.68775	
3	1	TO 2	0.02145	-0.01948	0.78874	0.80022	
3	2	TO 3	0.02085	0.02489	0.80022	0.77533	
3	3	TO 4	0.01681	0.03043	0.77533	0.74490	
3	4	TO 5	0.01300	0.02893	0.74490	0.71597	
3	5	TO 6	0.01188	-0.00520	0.71597	0.72117	
5	1	TO 2	0.01541	-0.00267	0.68394	0.68661	
5	2	TO 3	0.01534	0.00347	0.68661	0.68315	
5	3	TO 4	0.01492	0.00517	0.68315	0.67797	
5	4	TO 5	0.01438	0.00621	0.67797	0.67176	
5	5	TO 6	0.01418	-0.00122	0.67176	0.67298	

SAND SETTLEMENTS							

***** SETTLEMENT IN SAND LAYERS *****						33.3000	
THE STRAIN WEIGHTED AVERAGE BLOWCOUNT -							
LAYER			MEYERHOF				
NUMBER							
4			0.0090				
TOTAL SAND			0.0090				
SETTLEMENT							
TOTAL CLAY			1.6746				
SETTLEMENT							
TOTAL PROFILE			1.6835				
SETTLEMENT							

TIME-SETTLEMENT RELATIONSHIPS							

*****COEFFICIENT OF CONSOLIDATION*****							
(CU)							
LAYER NO.			CU				
2			50.FT./DAY				
3			1.2700				
5			0.7000				
			0.4700				
SETTLEMENT PER LAYER AT THE INPUT INPUT							
TIMES		SETTLEMENT		DEGREE OF CONSILADTION			
(DAYS)		(FEET)		(UN)			
		LAYER		2			
50.00		-0.0331		-2.50			
75.00		0.0000		0.00			
200.00		0.4233		31.98			
300.00		0.8808		66.54			
350.00		1.0121		76.45			
400.00		1.1029		83.31			
500.00		1.2138		91.60			
600.00		1.2891		95.87			
1000.00		1.3204		99.75			

(Continued)

Table 9 (Concluded)

REEDOUT	15:26:15	2/13/79
	LAYER 3	
50.00	-0.0366	-16.84
75.00	-0.0173	-7.95
200.00	0.1031	47.41
300.00	0.2022	93.00
350.00	0.2144	98.59
400.00	0.2163	99.49
500.00	0.2173	99.93
600.00	0.2174	99.99
1000.00	0.2174	100.00
	LAYER 5	
50.00	-0.0088	-6.57
75.00	-0.0043	-3.21
200.00	0.0304	22.79
300.00	0.0772	57.87
350.00	0.0907	68.04
400.00	0.1008	75.58
500.00	0.1146	85.95
600.00	0.1226	91.92
1000.00	0.1322	99.12

TOTAL SETTLEMENT OF PROFILE AT TIMES INPUT

TIMES (DAYS)	SETTLEMENT (FEET)	DEGREE OF CONSOLIDATION (UN)
50.00	-0.0784	-4.68
75.00	-0.0215	-1.29
200.00	0.5568	33.25
300.00	1.1602	69.28
350.00	1.3172	78.66
400.00	1.4199	84.79
500.00	1.5457	92.31
600.00	1.6091	96.09
1000.00	1.6700	99.73

(Figure 7).^{*} Table 10 shows the results. As can be seen, the computer and hand solution agree very closely.

30. Settlement in one of the clay layers (layer 2) determined from MAGSETII was compared to hand solutions for that layer using Terzaghi's theory. Table 11 shows these results. The computer results compare well with the hand solutions. It must be remembered that the theory is simplified to apply to the soil and load conditions, so these results are only an estimate.

31. Hand calculation of the degree of consolidation of the clay layers was based on the methods in EM 1110-2-1904 for clay material. The results are presented in Table 12. There are no noticeable differences in the results of the computer and hand calculations.

32. Settlement due to the compression of the sand was calculated by Meyerhof's method using a vertical strain influence factor. The settlement produced by MAGSETII was 0.009 ft, whereas hand calculations produced 0.007 ft, values which are very close. Again, it must be remembered that these are only estimates and hand calculations require some interpolation.

Example Problem 2

33. Example Problem 2 was taken from EM 1110-2-1904. A plan view of the problem is shown in Figure 8. Appendix A to EM 1110-2-1904, which describes the problem and includes hand computations, is included as Figure 9.

Input/output

34. Input to program I0016 is shown in Table 13. Output from the program is shown in Table 14. Using the stress information provided by program I0016, input to program MAGSETII was prepared and is shown in Table 15. Output from this program is included in Table 16.

^{*} This chart is from notes by Prof. Robert D'Andrea to Course No. CE3040, "Soil Mechanics," Worcester Polytechnic Institute, Worcester, Mass., 1975.

SCALE OF DISTANCE, $OQ = \text{DEPTH } Z$
AT WHICH STRESS IS COMPUTED

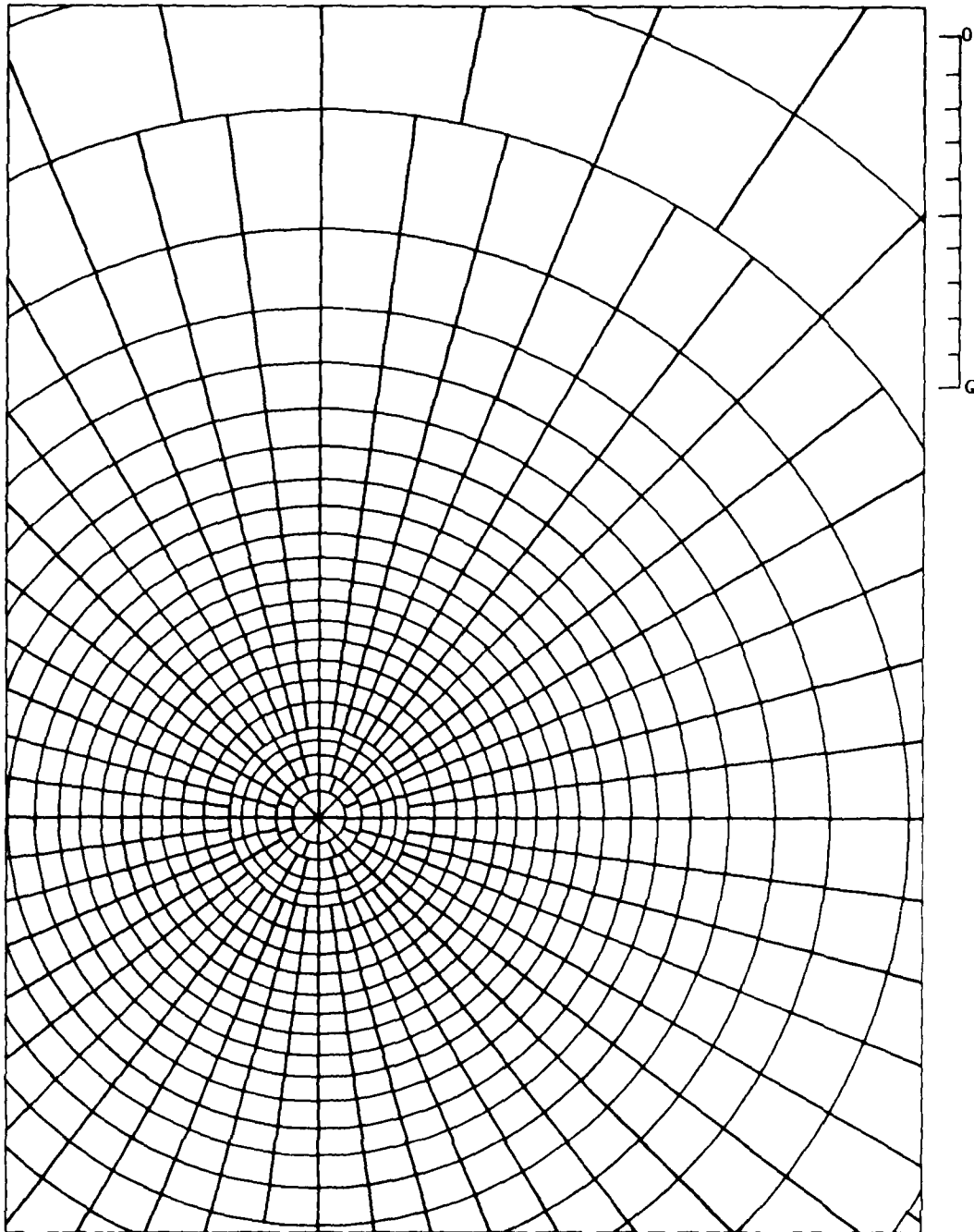


Figure 7. Newmark's influence chart for vertical pressure
(influence value = 0.001)

Table 10
Comparison of I0016 and Hand Solutions for Vertical
Stresses in Example Problem 1

Depth ft	Vertical Stress, kips/ft ²	
	I0016 Solution	Hand Solution
7.50	0.882	0.880
18.25	0.509	0.511
56.75	0.103	0.115

Table 11
Comparison of MAGSETII and Hand Solutions for Settlement in
Layer 2 of Example Problem 1

Increment No.	Settlement, ft	
	MAGSETII Solution	Hand Solution
1	-0.10946	-0.109
2	0.21768	0.215
3	0.74912	0.756
4	0.56025	0.560
5	-0.09385	-0.093

Table 12
Comparison of MAGSETII and Hand Solutions for Rate of Settlement
in Layer 2 of Example Problem 1

Time days	MAGSETII Solution		Hand Solution	
	Settlement ft	Degree of Consolidation percent	Settlement ft	Degree of Consolidation percent
50	-0.0331	-2.5	-0.037	-3
75	0.000	0.0	0.000	0
200	0.4233	31.98	0.50	37
300	0.8808	66.54	0.98	72
350	1.0121	76.45	1.08	81
400	1.1028	83.31	1.21	90
500	1.2138	91.69	1.25	94
600	1.2691	95.87	1.29	97
1000	1.32044	99.75	1.32	99

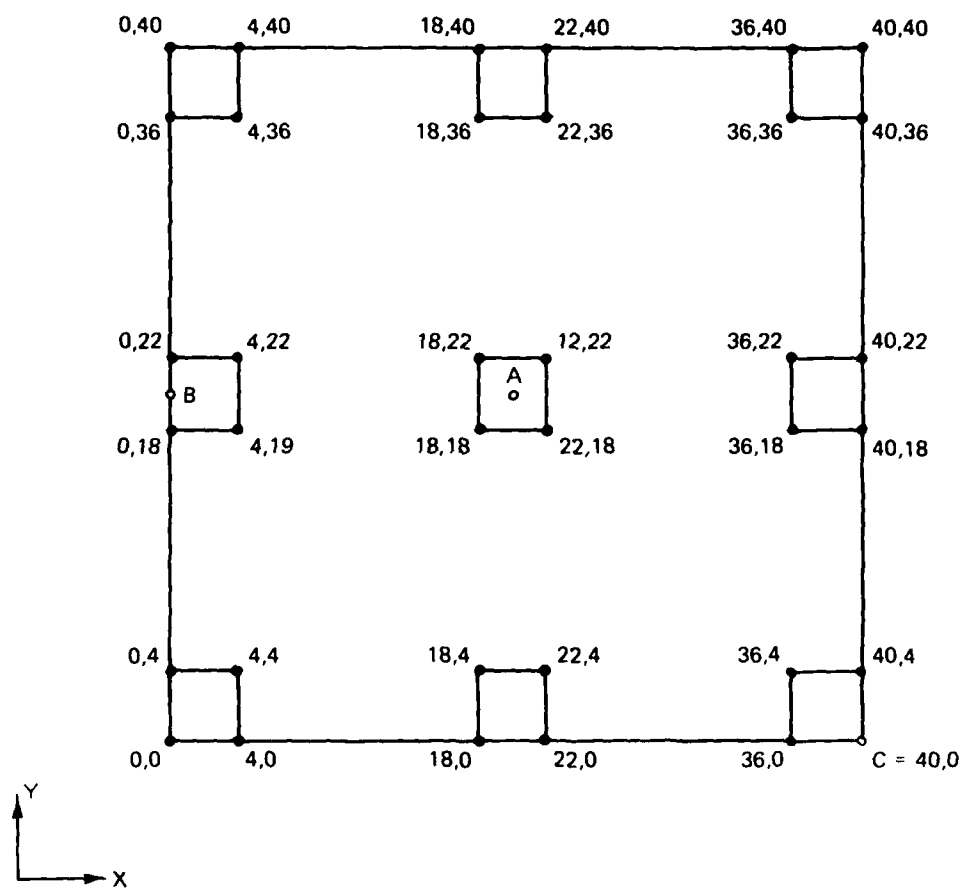


Figure 8. Plan view of problem 3

APPENDIX A

ILLUSTRATIVE PROBLEM—SETTLEMENT ANALYSIS

The Problem. Determine the total settlement resulting from a buried clay stratum and the time-settlement rate for a structure supported by nine 4- by 4-foot footings located at an elevation 5 feet below the natural ground surface. The foundation plan for the structure and the soil conditions beneath the structure are shown on Plate No. 1. The gross unit load on each footing is 2 tons per square foot. The construction rate of load will be applied uniformly in the first 60 days and the remaining 25 percent of the load will be applied uniformly during the next 30 days. The amount of rebound, resulting from the excavation before the construction load is applied, is assumed to be negligible. Consolidation test data for a representative sample of the clay stratum are shown on Plates Nos. 2 and 8 on which are plotted pressure-void ratio and time-settlement data, respectively, for the sample tested. Examination of the consolidation data shows the clay to be normally consolidated.

Total Settlement. In order to determine the differential settlement to be expected between footings, the settlement must be computed for several points such as A, B, and C, Plate No. 1. Proceed with the analysis as follows:

(1) Construct the load-depth diagram for the existing overburden conditions, Plate No. 3. Since the clay stratum is only 20 feet thick it is safe to assume that the pressure distribution is uniform from top to bottom and that the pressure at the middle of the stratum (depth 25 feet) represents the average pressure in the stratum. Determine p_1 from the load-depth diagram, Plate No. 3, which at 25 feet is 1.15 tons per square foot. The overburden pressure, p_1 , is the same for all three points A, B, and C.

(2) The pressure due to the added load of the structure may be determined either as point loads, since the dimension-depth ratio is greater than 3, or as area loads. The area load method was selected for this problem because it is valid for all depths. It was assumed that the Boussinesq solution would best fit the soil conditions encountered in this problem. Plate No. 6, was constructed as described in paragraph 4-03e and is utilized for determining the vertical pressures at depths of 10 and 25 feet below the footings for each of the three points A, B, and C. The gross unit load of the footings must be corrected for the weight of 5 feet of sand which was excavated, to obtain the net load applied to the foundation. From Plate No. 3 the pressure due to 5 feet of sand is 0.31 ton per square foot.

Hence:

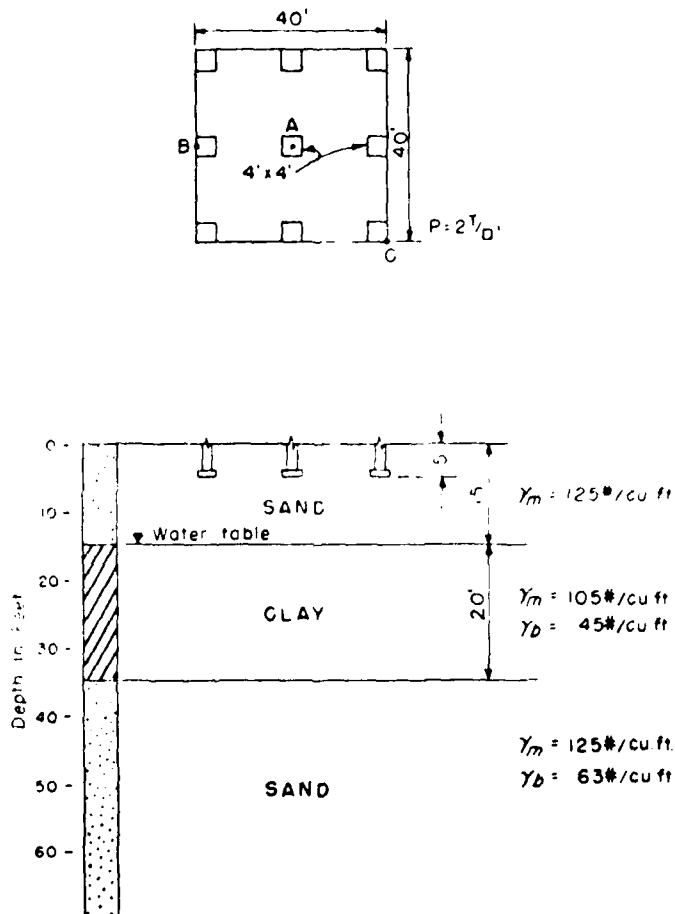
$$q = 2.00 - 0.31 = 1.69 \text{ tons per square foot (net load).}$$

Make up overlays of the foundation plan shown on Plate No. 1 with scale OQ equal to 10 and 25 feet for use with Plate No. 6. Using foundation plan with chart scale equal to 25 feet, place point A over the center of the chart. Count the number of influence areas on the chart which fall within the outlines of the individual footing areas. Since all footings have identical unit loads, the influence areas under all footings may be combined. A total of 25 influences is counted. Each influence area is equal to 0.001 q . Then for point A at a depth of 25 feet below the footing the pressure due to the structure load p_s is:

$$p_s = 25 \times 0.001 \times 1.69 = 0.042 \text{ tons per square foot.}$$

A-1

Figure 9. Appendix A to EM 1110-2-1904 (Sheet 1 of 9)



GENERAL PLAN
SHOWING STRUCTURE AND SOIL PROFILE

PART CXIX, CHAPTER 4
January 1963

Repeat the above procedure for other points and depths. The results for this problem are tabulated as follows:

Depth below footing	Point	Number of influence areas	p_s tons per sq. ft.
10	A	81	0.136
10	B	72	.122
10	C	66	.112
25	A	43	.073
25	B	33	.056
25	C	25	.042

Construct a load-depth diagram, Plate No. 6, using the above-computed values of pressures.

(3) Using Plate No. 7, determine p_s at the middle of the clay stratum which is located 20 feet below the bottom of the footing for points A, B, and C. Then, $p_2 = p_1 + p_s$. After obtaining p_2 , determine values of the void ratios e_1 and e_2 corresponding to p_1 and p_2 , by use of the pressure-void ratio curve, Plate No. 2. The total settlement ΔH may be obtained by the relationship:

$$\Delta H = \frac{e_1 - e_2}{1 + e_1} 2H_1$$

Results of the foregoing operations are summarized below.

Point	A	B	C
p_1	1.15	1.15	1.15
p	.08	.07	.06
p_2	1.23	1.22	1.21
e_1	1.044	1.044	1.044
e_2	1.035	1.037	1.038
$e_1 - e_2$	.009	.007	.006
$1 + e_1$	2.044	2.044	2.044
$2H$	20	20	20
ΔH	.09	.07	.06

Differential settlement between points A and B is 0.02 foot and between points A and C is 0.03 foot.

Time-settlement rate. Using Plate No. 10, the time for 50 percent consolidation of the laboratory specimen 1.25 inches in thickness is found to be 8.1 minutes. The time for 50 percent consolidation of the field stratum is then found by the use of the relationship:

$$t_{90} = \left(\frac{2H}{2H} \right)^2 t_{50}$$

Substituting:

$$t_{90} = \left(\frac{20 \text{ ft}}{1.25 \text{ inches}/12} \right)^2 (8.1 \text{ minutes})$$

$$t_{90} = 298,598 \text{ minutes} = 207.4 \text{ days.}$$

A-2

*Corrections and/or deletions made June 1955 in accordance with errata issued to date.

Figure 9. (Sheet 3 of 9)

Using the relationship in equation (19) as follows:

$$t_{10} = \frac{t_{50}}{T_{50}} T_u \frac{t_{50}}{0.13C}$$

compute the time for various percents consolidation, substituting values of T_u found in Table 1. Substituting, for 10 percent consolidation

$$t_{10} = \frac{298,598 \text{ min.}}{0.196} \times 0.0077 = 11,730 \text{ min.} = 14 \text{ days}$$

Results of the computations for the various percents of consolidation are tabulated below.

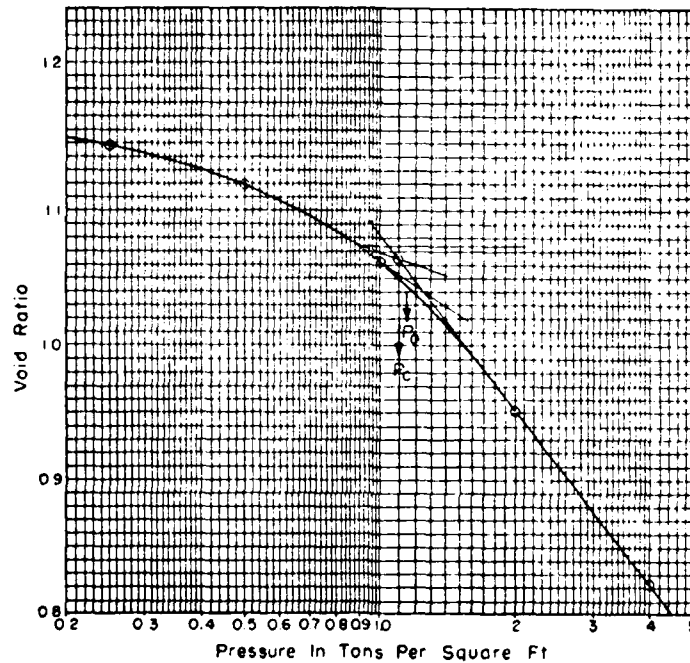
U%	T_u	t_{10} Minutes	Days
10	0.0077	11,730	8.14
20	.0314	47,836	32.8
30	.0707	107,708	74.8
40	.126	191,955	133.3
50	.196	298,597	207.3
60	.286	435,709	302.6
70	.403	613,954	426.3
80	.567	863,801	599.9
90	.848	1,291,893	897.1
95	1.129	1,719,985	1194.4

Since the time rate for construction is not uniform, it should be divided into convenient increments such as 25 percent of the load. It is assumed that each 25 percent increment will then cause approximately 25 percent of the total consolidation, and the settlement resulting from each increment is assumed to start at the half-time for the application of increment of load. To construct a loading diagram as shown on Plate 12, divide the load application into four 25 percent increments. Draw a time-settlement curve for each increment, starting at the half-time for each increment and using time values tabulated above. The percents consolidation will be divided by 4 in each case. The time-settlement curve for construction loading is then obtained by adding the ordinates of each increment time-settlement curve and drawing a smooth curve through the points so obtained. Adjust the initial portion of the curve by starting the curve at zero time and settlement.

A-3

Figure 9. (Sheet 4 of 9)

GPO 893423



Note: Initial thickness of sample 1.25 inches.

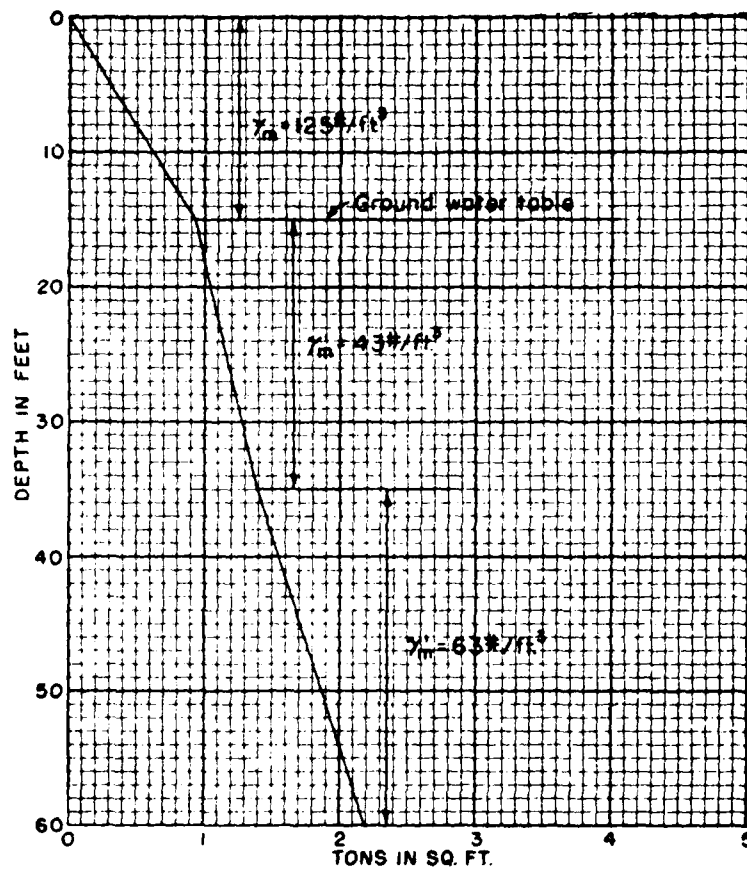
PRESSURE - VOID RATIO CURVE
FOR CLAY STRATUM BELOW
STRUCTURE ON PLATE NO. 1

ENGINEERING MANUAL PART CXIX CHAPTER 4

PLATE NO. 2

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Figure 9. (Sheet 5 of 9)



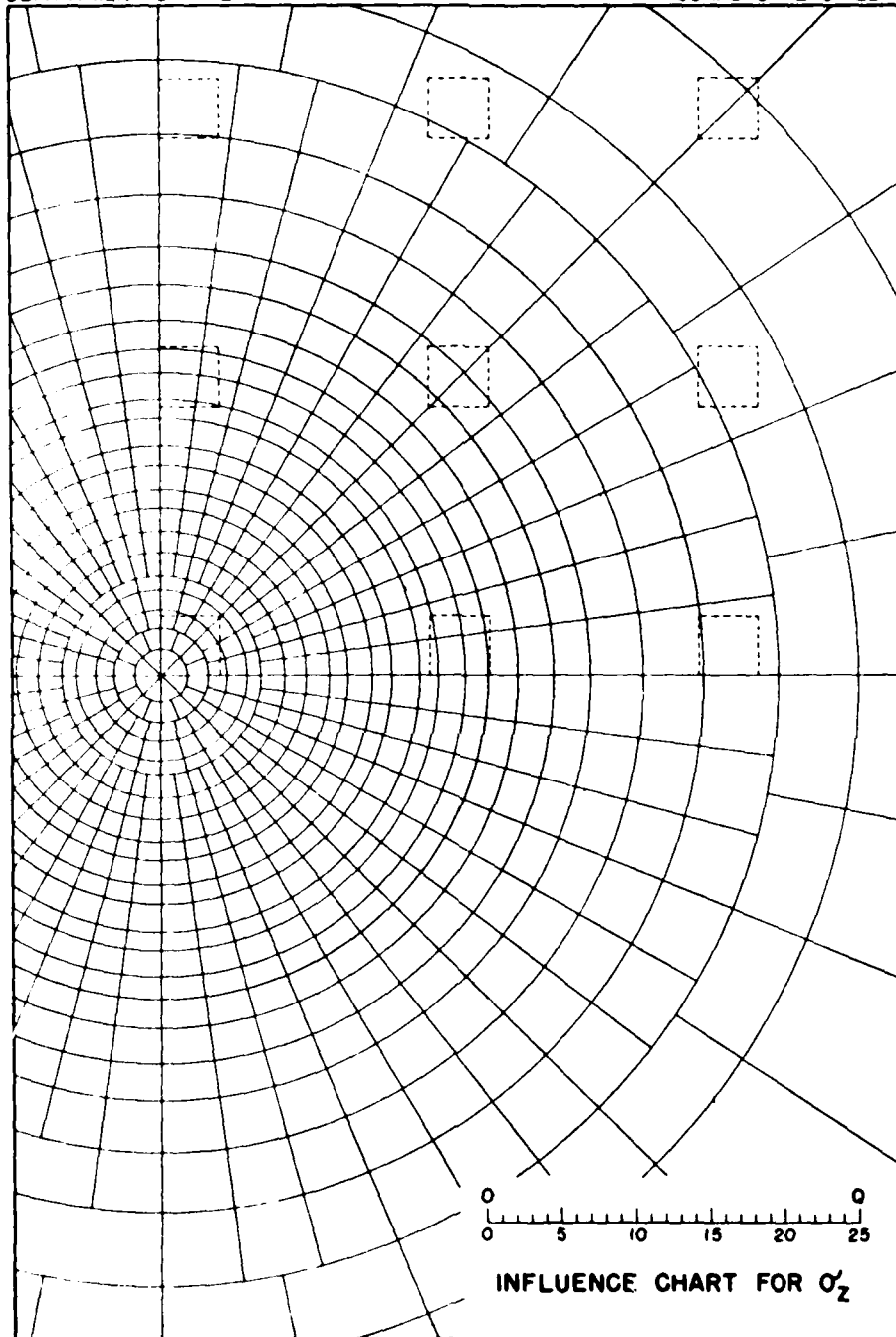
**LOAD DEPTH DIAGRAM
OVERBURDEN PRESSURE**

ENGINEERING MANUAL PART CXIX CHAPTER 4

PLATE NO. 3

24

Figure 9. (Sheet 6 of 9)

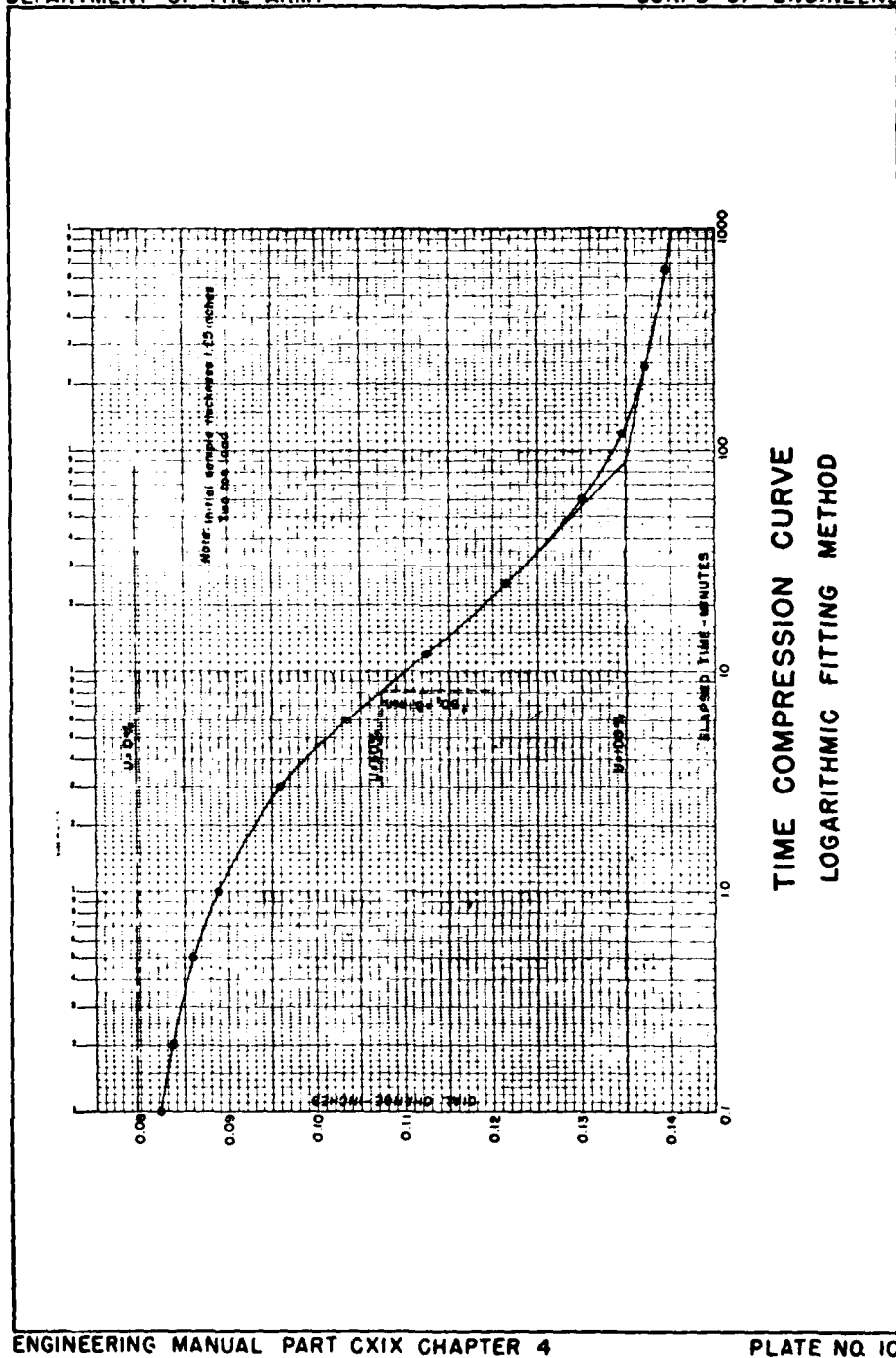


ENGINEERING MANUAL PART CXIX CHAPTER 4

PLATE NO 6

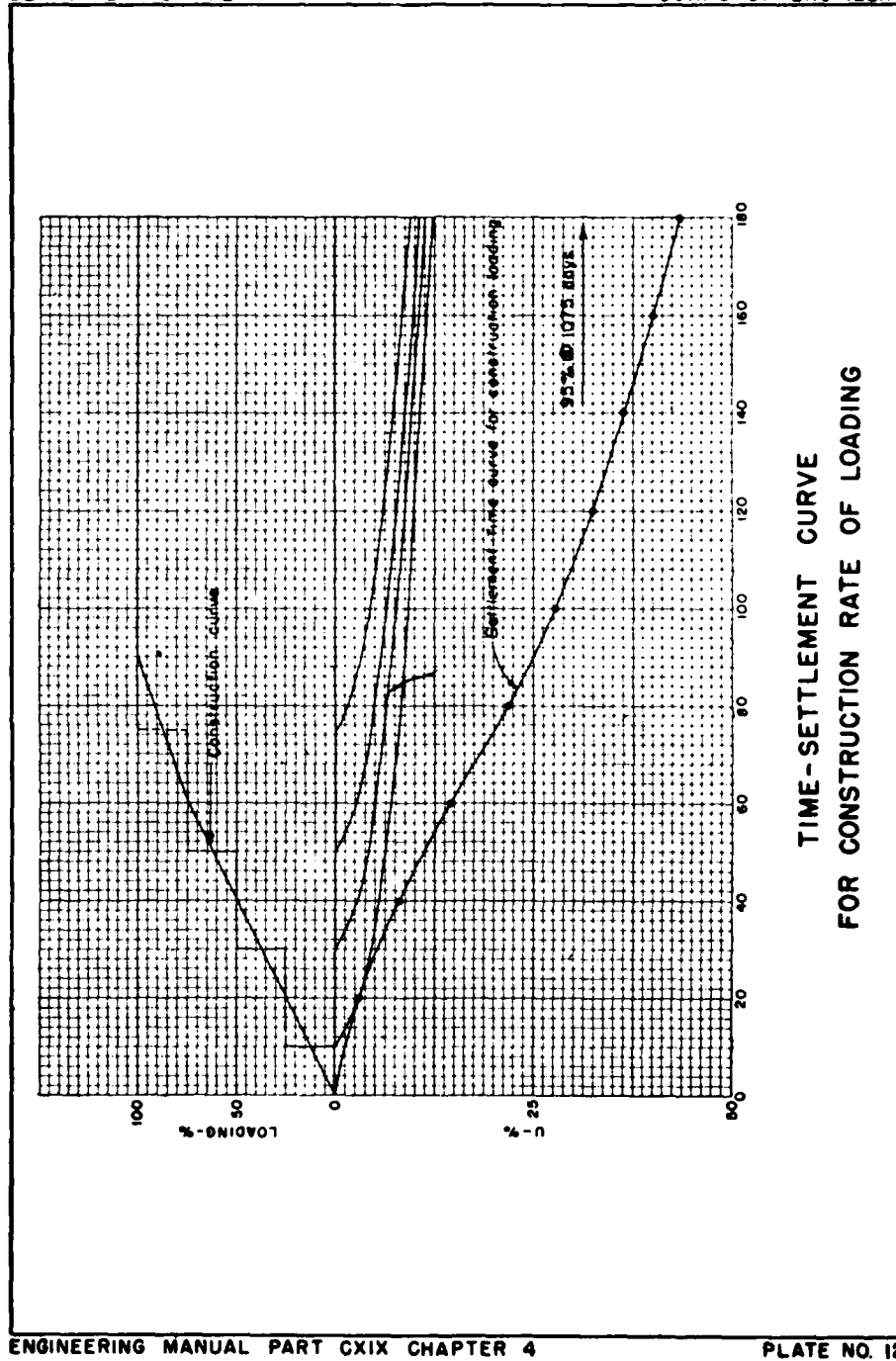
87

Figure 9. (Sheet 7 of 9)



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Figure 9. (Sheet 8 of 9)



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Figure 9. (Sheet 9 of 9)

Table 13
Input Data File for Program 10016
(Example Problem 2)

LIST RLMBS

```

1000 JAN 22, 1979
1010 SAMPLE PROBLEM
1020 9 4FT. BY 4FT. FOOTINGS
1030 RLM
1040 COMPARE TO EM1110-2-1904
1060 1 9 (KODE, NAREA)
1070 1.00 0.0 0.0 0.0 0.0 0.0 4.0 4.0 4.0 4.0 0.0
1080 1.00 0.0 18.0 0.0 18.0 4.0 22.0 4.0 22.0 0.0
1090 1.00 0.0 36.0 0.0 36.0 4.0 40.0 4.0 40.0 0.0
1100 1.00 0.0 0.0 18.0 0.0 22.0 4.0 22.0 4.0 18.0
1110 1.00 0.0 18.0 18.0 18.0 22.0 22.0 22.0 22.0 18.0
1120 1.00 0.0 36.0 18.0 36.0 22.0 40.0 22.0 40.0 18.0
1130 1.00 0.0 0.0 36.0 0.0 40.0 4.0 40.0 4.0 36.0
1140 1.00 0.0 18.0 36.0 18.0 40.0 22.0 40.0 22.0 36.0
1150 1.00 0.0 36.0 36.0 36.0 40.0 40.0 40.0 40.0 36.0
1160 2 1 0.0 NDIST, NWEST, AMU
1170 0.0 40.0 10.0 0.0 0.0 10.0 0.0 0.0
1171 2 1 0.0
1180 0.0 40.0 10.0 0.0 0.0 10.0 0.0 20.0
1181 2 1 0.0
1190 0.0 40.0 10.0 0.0 0.0 25.0 0.0 0.0
1191 2 1 0.0
1200 0.0 40.0 10.0 0.0 0.0 25.0 0.0 20.0
1210 0 0 0.0 ← (STOP THE PROBLEM)

```

TITLE

AINTL. FINAL, DELTA, XP, YP, ZP, SLP, BLINE

Q(1), ZLAY(1), XC(1,1), YC(1,1), XC(2,1), YC(2,1),
 XC(3,1), YC(3,1), XC(4,1), YC(4,1)

Table 14
Output Data File for Program I0016
(Example Problem 2)

RLMSB 10. 3.59 2/14/79

JAN 22.1979
SAMPLE PROBLEM
9 4FT BY 4FT FOOTINGS
RLM
COMPARE TO EM1110-2-1904

BOUSSINESQ SOLUTION

HORIZONTAL STRESS DISTRIBUTION AT DEPTH(Z) = 10 00

Y-COORDINATE	X-COORDINATE	ELASTIC SOLUTION VERTICAL STRESS	NORMAL LOADING VERTICAL STRESS
0	0	0 064	0 064
0	10 00	0 037	0 037
0	20 00	0 072	0 072
0	30 00	0 037	0 037
0	40 00	0 064	0 064

NUMBER OF AREAS USED IN CALCULATION = 9

NOTE-ALL Z VALUES ARE REFERENCED TO THE LOWEST PART OF THE INPUT.
CONFIGURATION

JAN 22.1979
SAMPLE PROBLEM
9 4FT BY 4FT FOOTINGS
RLM
COMPARE TO EM1110-2-1904

BOUSSINESQ SOLUTION

HORIZONTAL STRESS DISTRIBUTION AT DEPTH(Z) = 10 00

Y-COORDINATE	X-COORDINATE	ELASTIC SOLUTION VERTICAL STRESS	NORMAL LOADING VERTICAL STRESS
20 00	0	0 072	0 072
20 00	10 00	0 042	0 042
20 00	20 00	0 082	0 082
20 00	30 00	0 042	0 042
20 00	40 00	0 072	0 072

NUMBER OF AREAS USED IN CALCULATION = 9

NOTE-ALL Z VALUES ARE REFERENCED TO THE LOWEST PART OF THE INPUT.
CONFIGURATION

(Continued)

Table 14 (Concluded)

JAN 22.1979
SAMPLE PROBLEM
9 4FT BY 4FT FOOTINGS
RLM
COMPARE TO EM1110-2-1904

BOUSSINESQ SOLUTION

HORIZONTAL STRESS DISTRIBUTION AT DEPTH(Z) = 25 00

Y-COORDINATE	X-COORDINATE	ELASTIC SOLUTION VERTICAL STRESS	NORMAL LOADING VERTICAL STRESS
0	0	0 023	0 023
0	10 00	0 027	0 027
0	20 00	0 029	0 029
0	30 00	0 027	0 027
0	40 00	0 023	0 023

NUMBER OF AREAS USED IN CALCULATION = 9

NOTE-ALL Z VALUES ARE REFERENCED TO THE LOWEST PART OF THE INPUT.

RLMSB

10 3:59 2/14/79

CONFIGURATION

JAN 22.1979
SAMPLE PROBLEM
9 4FT BY 4FT FOOTINGS
RLM
COMPARE TO EM1110-2-1904

BOUSSINESQ SOLUTION

HORIZONTAL STRESS DISTRIBUTION AT DEPTH(Z) = 25 00

Y-COORDINATE	X-COORDINATE	ELASTIC SOLUTION VERTICAL STRESS	NORMAL LOADING VERTICAL STRESS
20 00	0	0 029	0 029
20 00	10 00	0 035	0 035
20 00	20 00	0 038	0 038
20 00	30 00	0 035	0 035
20 00	40 00	0 029	0 029

NUMBER OF AREAS USED IN CALCULATION = 9

NOTE-ALL Z VALUES ARE REFERENCED TO THE LOWEST PART OF THE INPUT.
CONFIGURATION

Table 15

SECOND RUN -

THIRD RUN -

Table 16
Output Data File for Program MAGSETII
(Example Problem 2)

```

RLMMN                                     9.57  S   2/14/79
1
*****
*                                     *
*          MAGSET-II                 *
*                                     *
* MAGNITUDE OF SETTLEMENT OF *
* A MULTI-LAYERED SOIL SYSTEM *
*                                     *
*****

*****
* SPECIFICATIONS FOR *
* PROBLEM NO 1 *
*****

***** TITLE *****
COMPARISON TO EM1110-2-1904 PROBLEM
***** UNITS *****
          LENGTH      FORCE
          FEET      TON S

*****
* SOIL PROFILE *
* DESCRIPTION *
*****

          DATUM ELEVATION      0
          DIFFERENCE IN ELEVATION      0
          INTERFACE      DATUM
          DEPTH      ELEVATIONS      THICKNESS      UNIT
          NUMBER      TYPE
1      INCOMP      15 00      -15 00      15 00      0 0625
2      CLAY      35 00      -35 00      20 00      0 0525

          UNIT WEIGHT      GROUND WATER      GROUND WATER
          OF WATER      LEVEL      DATUM ELEVATION
          0 0313      15 00      -15 00

*****
* INSITU EFFECTIVE STRESS *
*****

          LAYER      INPUT      CALCULATED      INSITU
          NUMBER      VALUE      VALUE      STRESS
          1      -      0 4688      0 4688
          2      -      1 1495      1 1495

*****
* CLAY SETTLEMENT DATA *
*****

EFFECTIVE STRESS INCREMENTS INPUT BY
          A DISTRIBUTION FUNCTION
***** STRESS INCREMENTS FOR STRATUM *****
          POINT NUMBER      STRESS INCREMENT
          1      1 2675
          2      0 4225

***** STRESS DISTRIBUTION FUNCTION *****
          LAYER      VALUE
          NUMBER
          2      0 0380

***** EFFECTIVE STRESS HISTORY *****
          LAYER NO      PT NO      STRESS INCREMENT      STRESS VALUES
          2      1      0 0482      1 1977
          2      2      0 0161      1 2137

```

(Continued)

Table 16 (Continued)

RLMMH

9:57.8 2/14/79

```

+      DEFORMATION CURVES INPUT BY      COORDINATE POINTS
      ***** COORDINATES OF POINTS ON THE DEFORMATION CURVES *****
      LAYER POINT      VOID RATIO      STRESS      REBOUND      REBOUND      STRESS
      NUMBER NUMBER      VOID RATIO      STRESS      REBOUND      REBOUND      STRESS
      2      1      1 1500      0 2400
      2      2      1 1200      0 5000      1 1500      0 2400
      2      3      1 0600      1 0000      1 1200      0 5000
      2      4      0 9500      2 0000      1 0600      1 0000
      2      5      0 8200      4 0000      0 9500      2 0000
  
```

```

      ***** SLOPES ON THE DEFORMATION CURVES *****
      LAYER LINE      CC      CE      CC      CE
      NUMBER NUMBER      CC      CE      (STRAIN)      (STRAIN)
      2      1      0 0941      0 0941      0 0438      0 0438
      2      2      0 1993      0 1993      0 0540      0 0940
      2      3      0 3654      0 3654      0 1774      0 1774
      2      4      0 4319      0 4319      0 2215      0 2215
  
```

 * CLAY SETTLEMENT CONTRIBUTIONS *

```

      ***** SETTLEMENT BY LAYERS *****
      LAYER STRESS INTERVAL      INCREMENTAL
      NUMBER      SETTLEMENT
      2      1 TO 2      0 06393
      2      2 TO 3      0 02074
      2      LAYER HISTORY      0 08467
  
```

```

      ***** SETTLEMENT BY STRESS INTERVAL *****
      STRESS INTERVAL      SETTLEMENT
      1 TO 2      0 06393
      2 TO 3      0 02074
  
```

TOTAL CLAY SETTLEMENT 0 08467

 * CLAY COMPRESSIBILITIES *

```

      LAYER STRESS      MV      DELTA E      E1      E2
      2      1 TO 2      0 06636      0 00651      1 03789      1 03138
      2      2 TO 3      0 06480      0 00211      1 03138      1 02926
  
```

THERE ARE NO SAND LAYERS IN THE SOIL PROFILE

 * DEGREE OF CONSOLIDATION *

***** COEFFICIENT OF CONSOLIDATION *****
 (CU)

```

      LAYER NO.      CU
      2      50 FT / DAY
      0 0950
  
```

(Continued)

Table 16 (Continued)

RLNMM	9.57 8		2/14/79
DEGREE OF CONSOLIDATION		TIME FACTOR	DAYS
UX	TV		
LAYER 2			
5.00%	0.0020		2.07
10.00%	0.0079		8.28
15.00%	0.0177		18.63
20.00%	0.0315		33.11
25.00%	0.0492		51.74
30.00%	0.0708		74.51
35.00%	0.0963		101.41
40.00%	0.1258		132.46
45.00%	0.1593		167.64
50.00%	0.1966		206.97
55.00%	0.2386		251.11
60.00%	0.2863		301.35
65.00%	0.3404		358.30
70.00%	0.4028		424.05
75.00%	0.4767		501.81
80.00%	0.5671		596.99
85.00%	0.6837		719.69
90.00%	0.8480		892.63
95.00%	1.1289		1188.27

* MAGSET-II *			
* MAGNITUDE OF SETTLEMENT OF *			
* A MULTI-LAYERED SOIL SYSTEM *			

* SPECIFICATIONS FOR *			
* PROBLEM NO. 1 *			

***** TITLE *****			
COMPARISON TO EM1110-2-1904 PROBLEM			
***** UNITS *****			
LENGTH FORCE			
FEET TON S			

* SOIL PROFILE *			
* DESCRIPTION *			

DATUM ELEVATION - 0			
DIFFERENCE IN ELEVATION - 0			
LAYER	SOIL	INTERFACE	DATUM
NUMBER	TYPE	DEPTH	ELEVATIONS
		0	0
1	INCOMP	15.00	-15.00
2	CLAY	35.00	-35.00
			THICKNESS
			15.00
			20.00
			UNIT WEIGHT
			0.0625
			0.0525
UNIT WEIGHT OF WATER 0.0313			
GROUND WATER LEVEL 15.00			
GROUND WATER DATUM ELEVATION -15.00			

* INSITU EFFECTIVE STRESS *			

LAYER	INPUT	CALCULATED	INSITU
NUMBER	VALUE	VALUE	STRESS
1	-	0.4688	0.4688
2	-	1.1495	1.1495

(Continued)

Table 16 (Continued)

```

RLMM                      9 57.8   2/14/79

*****
* CLAY SETTLEMENT DATA *
*****

EFFECTIVE STRESS INCREMENTS INPUT BY
+ A DISTRIBUTION FUNCTION
***** STRESS INCREMENTS FOR STRATUM *****
POINT NUMBER    STRESS INCREMENT
1                1 2675
2                0 4225

***** STRESS DISTRIBUTION FUNCTION *****
LAYER
NUMBER          VALUE
2              0 0290

***** EFFECTIVE STRESS HISTORY *****
LAYER NO    PT NO    STRESS INCREMENT    STRESS VALUES
2           1        0 0368            1 1863
2           2        0 0123            1 1985

+ DEFORMATION CURVES INPUT BY
COORDINATE POINTS
***** COORDINATES OF POINTS ON THE DEFORMATION CURVES *****
LAYER POINT    VOID RATIO    STRESS    REBOUND    VOID RATIO    STRESS
NUMBER NUMBER
2       1       1 1500        0 2400
2       2       1 1200        0 5000        1 1500        0 2400
2       3       1 0600        1 0000        1 1200        0 5000
2       4       0 9500        2 0000        1 0600        1 0000
2       5       0 8200        4 0000        0 9500        2 0000

***** SLOPES ON THE DEFORMATION CURVES *****
LAYER LINE    CC          CE          CC          CE
NUMBER NUMBER  (STRAIN) (STRAIN)
2       1      0 0941      0 0941      0 0438      0 0438
2       2      0 1993      0 1993      0 0940      0 0940
2       3      0 3654      0 3654      0 1774      0 1774
2       4      0 4319      0 4319      0 2215      0 2215

*****
* CLAY SETTLEMENT CONTRIBUTIONS *
*****

***** SETTLEMENT BY LAYERS *****
LAYER STRESS INTERVAL    INCREMENTAL
NUMBER
2      1 TO 2            0 04902
2      2 TO 3            0 01500
2      LAYER HISTORY     0 06503

***** SETTLEMENT BY STRESS INTERVAL *****
STRESS INTERVAL    SETTLEMENT
1 TO 2              0 04902
2 TO 3              0 01500

TOTAL CLAY SETTLEMENT    0 06503

*****
* CLAY COMPRESSIBILITIES *
*****

```

(Continued)

Table 16 (Continued)

RLMM 9.57. 8 2/14/79 PAGE 9

```
*****
LAYER  STRESS      MU      DELTA E      E1      E2
  2      1 TO 2      0.06668  0.00500  1.03789  1.03289
  2      2 TO 3      0.06547  0.00163  1.03289  1.03126
```

THERE ARE NO SAND LAYERS IN THE SOIL PROFILE

```
*****
*DEGREE OF CONSOLIDATION*
*****
```

COEFFICIENT OF CONSOLIDATION
(CU)

LAYER NO 2 CU
SQ FT /DAY
0.0950

DEGREE OF CONSOLIDATION U_x TIME FACTOR TV DAYS

DEGREE OF CONSOLIDATION U _x	TIME FACTOR TV	DAYS
5.00%	0.0020	2.07
10.00%	0.0079	8.28
15.00%	0.0177	18.63
20.00%	0.0315	33.11
25.00%	0.0492	51.74
30.00%	0.0708	74.51
35.00%	0.0963	101.41
40.00%	0.1258	132.46
45.00%	0.1593	167.64
50.00%	0.1966	206.97
55.00%	0.2386	251.11
60.00%	0.2863	301.35
65.00%	0.3404	358.30
70.00%	0.4028	424.05
75.00%	0.4767	501.81
80.00%	0.5671	596.99
85.00%	0.6837	719.69
90.00%	0.8480	892.63
95.00%	1.1289	1188.27

```
1 *****
* MAGSET-II *
* MAGNITUDE OF SETTLEMENT OF *
* A MULTI-LAYERED SOIL SYSTEM *
*****
```

```
*****
* SPECIFICATIONS FOR *
* PROBLEM NO 1 *
*****
```

***** TITLE *****
COMPARISON TO EM1110-2-1904 PROBLEM
***** UNITS *****
LENGTH TON S FORCE
FEET

```
*****
* SOIL PROFILE *
* DESCRIPTION *
*****
```

DATUM ELEVATION - 0
DIFFERENCE IN ELEVATION - 0

(Continued)

Table 16 (Continued)

```

RLMM
9.57. 8 2/14/79

LAYER NUMBER    SOIL TYPE    INTERFACE DEPTH    DATUM ELEVATIONS    THICKNESS    UNIT WEIGHT
1      INCOMP      15 00      -15 00      15 00      0 0625
2      CLAY       35 00      -35 00      20 00      0 0525

UNIT WEIGHT OF WATER 0 0313
GROUND WATER LEVEL 15 00
GROUND WATER DATUM ELEVATION -15 00

*****
* INSITU EFFECTIVE STRESS *
*****

LAYER NUMBER    INPUT VALUE    CALCULATED VALUE    INSITU STRESS
1      -      0 4688      0 4688
2      -      1 1495      1 1495

*****
* CLAY SETTLEMENT DATA *
*****

EFFECTIVE STRESS INCREMENTS INPUT BY
+ A DISTRIBUTION FUNCTION

***** STRESS INCREMENTS FOR STRATUM *****
POINT NUMBER    STRESS INCREMENT
1      1 2675
2      0 4225

***** STRESS DISTRIBUTION FUNCTION *****
LAYER NUMBER    VALUE
2      0 0230

***** EFFECTIVE STRESS HISTORY *****
LAYER NO.    PT NO.    STRESS INCREMENT    STRESS VALUES
2      1      0 0202      1 1787
2      2      0 0097      1 1884

DEFORMATION CURVES INPUT BY
+ COORDINATE POINTS

***** COORDINATES OF POINTS ON THE DEFORMATION CURVES *****
LAYER NUMBER    POINT NUMBER    VOID RATIO    STRESS    VOID RATIO    STRESS
2      1      1 1500      0 2400
2      2      1 1200      0 5000      1 1500      0 2400
2      3      1 0600      1 0000      1 1200      0 5000
2      4      0 9500      2 0000      1 0600      1 0000
2      5      0 8200      4 0000      0 9500      2 0000

***** SLOPES ON THE DEFORMATION CURVES *****
LAYER NUMBER    LINE NUMBER    CC    CE    CC (STRAIN)    CE (STRAIN)
2      1      0 0941      0 0941      0 0438      0 0438
2      2      0 1993      0 1993      0 0940      0 0940
2      3      0 3654      0 3654      0 1774      0 1774
2      4      0 4319      0 4319      0 2215      0 2215

```

(Continued)

Table 16 (Concluded)

RLMM

9-57-8 2/14/79

* CLAY SETTLEMENT CONTRIBUTIONS *

***** SETTLEMENT BY LAYERS *****			
LAYER NUMBER	STRESS INTERVAL		INCREMENTAL SETTLEMENT
2	1 TO 2		0 03901
2	2 TO 3		0 01279
2	LAYER HISTORY		0 05179

***** SETTLEMENT BY STRESS INTERVAL *****			
STRESS INTERVAL		SETTLEMENT OVER PROFILE	
1 TO 2		0 03901	
2 TO 3		0 01279	

TOTAL CLAY SETTLEMENT 0 05179

* CLAY COMPRESSIBILITIES *

LAYER	STRESS	MU	DELTA E	E1	E2
2	1 TO 2	0 06690	0 00397	1 03789	1 03391
2	2 TO 3	0 06593	0 00130	1 03391	1 03261

THERE ARE NO SAND LAYERS IN THE SOIL PROFILE

DEGREE OF CONSOLIDATION

*****COEFFICIENT OF CONSOLIDATION*****
(CU)

LAYER NO	CU
2	0 0950

DEGREE OF CONSOLIDATION UX	TIME FACTOR TV	DAYS
5 00%	LAYER 2 0 0020	2 07
10 00%	0 0079	8 28
15 00%	0 0177	18 63
20 00%	0 0315	33 11
25 00%	0 0492	51 74
30 00%	0 0708	74 51
35 00%	0 0963	101 41
40 00%	0 1258	132 46
45 00%	0 1593	167 64
50 00%	0 1966	206 97
55 00%	0 2386	251 11
60 00%	0 2863	301 35
65 00%	0 3404	358 30
70 00%	0 4028	424 05
75 00%	0 4767	501 81
80 00%	0 5671	596 99
85 00%	0 6837	719 69
90 00%	0 8480	892 63
95 00%	1 1289	1188 27

Comparison of results

35. The stress induction and settlement results for example problem 2 from EM 1110-2-1904 are compared with the computer solutions in Tables 17 and 18. It appears that although EM 1110-2-1904 states that the values are calculated at 25 ft below the footing, they really seem to be computed at 20 ft below the footing. The comparisons are very close.

36. The time-settlement results are compared in Table 19. Again, the results are very close showing the validity of the programs used.

Table 17

Comparison of I0016 and EM 1110-2-1904 Solutions for Stress Induction in Example Problem 2

Location	Stress Induction		EM 1110-2-1904 Solution
	I0016 Solution (Output × 1.69 tons/ft ²)		
	@ 25 ft	@ 20 ft	
A	0.064	0.073	0.073
B	0.049	0.058	0.056
C	0.039	0.046	0.042

Table 18

Comparison of MAGSETII and EM 1110-2-1904 Solutions for Settlement in Example Problem 2

Location	Settlement, ft		EM 1110-2-1904 Solution
	MAGSETII Solution		
	@ 25 ft	@ 20 ft	
A	0.085	0.094	0.09
B	0.065	0.071	0.07
C	0.052	0.063	0.06

Table 19
Comparison of MAGSETII and EM 1110-2-1904 Solutions for Rate
of Settlement in Example Problem 2

<u>Degree of Consolidation percent</u>	<u>Time, days</u>	
	<u>MAGSETII Solution</u>	<u>EM 1110-2-1904 Solution</u>
10	8.28	8.14
15	18.63	
20	33.11	32.8
25	51.74	
30	74.51	74.8
35	101.41	
40	132.46	133.3
45	167.64	
50	206.97	207.3
55	251.11	
60	301.35	302.6
65	358.30	
70	424.05	426.3
75	501.81	
80	596.99	599.9
85	719.69	
90	892.63	897.1
95	1188.27	1194.4

PART IV: EXAMPLE PROBLEM ILLUSTRATING
INPUT/OUTPUT FOR PROGRAM FD31

37. This Part contains an example problem solved using Program FD31. Other examples solved using FD31 are presented in Olson.

Input

38. Data input falls into three categories: (a) input/output control parameters, (b) raw data, and (c) program control. The input/output control parameters govern the form in which data are input and the amount of output and type of output to be printed out. Raw data consist of water table, drainage data, effective weights, layer depth, excess pore pressures, embankment description or load description, time table of construction for detail output, consolidation curve, and coefficient of permeability and coefficient of consolidation. The program control data consist of parameters controlling the accuracy of computations within a program.

39. The example problem soil profile (Figure 10) is a simple one for which Terzaghi's theory is applicable. The soil system consists of 1 ft of incompressible sand over 10 ft of clay over incompressible sand.

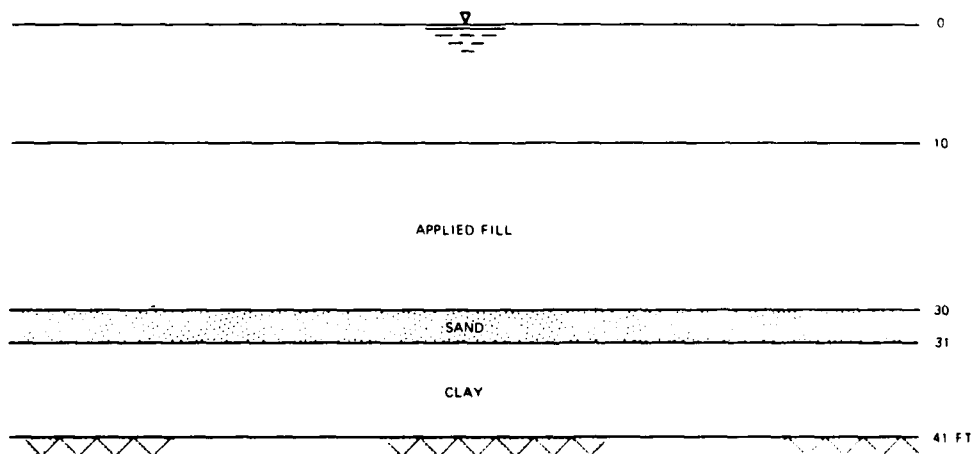


Figure 10. Soil profile for FD31 example problem

All layers are saturated and have submerged unit weights of 50 lb/ft^3 . The clay is linearly elastic and the consolidation curve passes through the points $(e, \bar{\sigma}) = (2.0075, 0 \text{ lb/ft}^2)$ and $(1.9500, 2300 \text{ lb/ft}^2)$. The clay has a constant coefficient of consolidation of $0.05 \text{ ft}^2/\text{day}$. Consolidation results from the application of 20 ft of fill at time zero. The fill has a total unit weight of 112.4 lb/ft^2 and is also saturated. The water table is 30 ft above the original ground surface.

40. The complete input is shown in conversational mode in Table 20. Values of various control parameters are indicated below with brief explanations:

- a. I01-I09. All 10 parameters are set to 1 for this example in order to obtain maximum output information.
- b. KODWT=C. The water table will be maintained at a constant elevation.
- c. TOPB=F. The upper boundary of natural soil is freely draining.
- d. BOTB=F. The bottom boundary is also freely draining.
- e. USEQO=T. The value of this parameter is not relevant for this problem and may be set at either T or F.
- f. SANDPP=F. The value of this parameter is not relevant either but should be set equal to either F or S.
- g. ALMX1=0.5. The value of this parameter is irrelevant to this problem because the loading is a single step loading.
- h. ALMX2=0.5. This is the upper limit on all values of A(IN) at time zero.
- i. ALMX3=20.5. This is the upper limit on values of A(IN) at time TL(JLFIN); i.e., the last point on the loading curve.
- j. CHGMIN=0.1. The value of CHGMIN is irrelevant because the coefficient of consolidation is constant.
- k. CHGLIM=1.0. The value of this parameter is irrelevant because of the constant coefficient of consolidation.
- l. FCV=1.0. The value of this parameter is also irrelevant because of the constant coefficient of consolidation.
- m. TOL=0.1. The Gauss-Seidel subroutine will continue iterating until no excess pore pressure in the system changes by more than 0.1 lb/ft^2 on the last iteration.
- n. ITERMX=100. If the number of iterations in the Gauss-Seidel subroutine reaches 100, the calculations will be aborted and the analysis stops.

Table 20

Input in the Conversational Mode for Program FD31 Example Problem

```

IF DATA IS TO BE READ FROM A DATA FILE
INPUT THE FILE NAME (8 CHARACTERS MAX.)
HIT CARRIAGE RETURN IF INPUT IS FROM TERMINAL
=

IF DATA IS TO BE SAVED TO A DATA FILE
INPUT THE FILE NAME (8 CHARACTERS MAX.)
HIT CARRIAGE RETURN IF NO FILE IS TO BE WRITTEN.
=

IF OUTPUT IS TO BE WRITTEN TO A FILE
INPUT THE FILE NAME (8 CHARACTERS MAX.)
HIT CARRIAGE RETURN IF OUTPUT IS TO COME TO TERMINAL.
=
DO YOU WISH TO HAVE ALL INPUT ECHOED ? (Y/N)
=N
INPUT TITLE FOR THIS RUN
=EXAMPLE PROBLEM FOR SETTLEMENT PACKAGE
ASSIGN VALUES OF 1 IF OUTPUT IS DESIRED, OTHERWISE 0.
I01 = RESIDUAL PORE PRESSURES AND EFFECTIVE STRESS
I02 = LOAD HISTORY
I03 = OUTPUT TIMES
I04 = E-P CURVES
I05 = INITIAL VALUES OF CV
I06 = 0 FOR DATA AT MIDHEIGHT OF LAYERS AND AT INTERFACES
      BETWEEN LAYERS
      = 1 FOR DATA AT ALL NODES AND INTERNODES
I07 = 1 IF DATA ARE TO BE OUTPUT ONLY AT TIMES TO<JO>
      = 0 IF DATA ARE TO BE OUTPUT AFTER EVERY TIME TC. IN THIS
        CASE, I06 IS AUTOMATICALLY SET AT 1
I08 = 0 FOR NO OUTPUT OF CONTROL PARAMETERS
      = 1 FOR OUTPUT OF CONTROL PARAMETERS
I01,I02,I03,I04,I05,I06,I07,I08
=1 1 1 1 1 1 1 1
ZMTD=DEPTH FROM ORIGINAL GROUND SURFACE TO THE WATER TABLE,
      POSITIVE DOWNWARDS (FEET)
ZMTF=DEPTH FROM A DATUM ESTABLISHED AT THE ELEVATION OF THE
      ORIGINAL GROUND SURFACE TO THE FINAL WATER TABLE,
      POSITIVE DOWNWARDS (FEET)
KODMT=S MEANS THE ELEVATION OF THE WATER TABLE IS CONSTANT
      R MEANS THE ELEVATION OF THE WATER TABLE RISES FROM
      EMTD TO EMTF AS A RESULT OF CONSTRUCTION OPERATIONS
      D MEANS THE ELEVATION OF THE WATER TABLE DROPS FROM
      EMTD TO EMTF INSTANTLY AT TIME ZERO
      S MEANS THE ELEVATION OF THE WATER TABLE ALWAYS IS THE
      ELEVATION OF THE ORIGINAL GROUND SURFACE AS THAT
      SURFACE SETTLES OR RISES.
TOPB = I FOR AN IMPERVIOUS UPPER BOUNDARY
      = F FOR A FREELY DRAINING UPPER BOUNDARY
BOTB = I FOR AN IMPERVIOUS LOWER BOUNDARY
      = F FOR A FREELY DRAINING LOWER BOUNDARY
USE00= T IF STATIC PORE PRESSURES ARE ZERO ABOVE THE WATER
      TABLE AT ALL TIMES
      = F IF STATPP(I)=(Z(I)-ZMTD)*62.4 AT ALL TIMES
SANDPP = F IF ALL SAND LAYERS DRAIN FREELY HORIZONTALLY
      = S IF SAND LAYERS ARE SEALED HORIZONTALLY
ZMTD,ZMTF,KODMT,TOPB,TOPB,BOPB,USE00,SANDPP
=-30.0 -30.0 C F F T F

```

(Continued)

Table 20 (Continued)

```

HL=NUMBER OF LAYERS OF SOIL (NOT COUNTING NEW FILL)
HL(L)=THICKNESS OF LAYER L AT TIME ZERO (FEET)
GAMPR(L)=SUBMERGED UNIT WEIGHT OF SOIL IN LAYER L AT TIME ZERO
      (PCF)
HZ(L)=NUMBER OF NODES IN ANY LAYER.
NUMBER OF LAYER
=2
INPUT HL,GAMPR,HZ FOR LAYER 2
=1.00 50.0 2
INPUT HL,GAMPR,HZ FOR LAYER 2
=10.0 50.0 11
ALMX1 = MAXIMUM ALPHA DURING LOADING OR UNLOADING
ALMX2 = MAXIMUM ALPHA DURING A NON-CONSTRUCTION PERIOD EXCEPT
      FOR TC.GT.TL(JLFIN-1)
ALMX3 = MAXIMUM ALPHA AT TC=TL(JLFIN)
CHGLIM = MAXIMUM ALLOWABLE CHANGE IN CV EXPRESSED AS A RATIO
CHGMIN = THE PROGRAM WILL NOT CALCULATE AVERAGE VALUES OF
      CV AND RECYCLE IF CHGMAX.LT.CHGMIN. RELEVANT ONLY FOR A
      VARIABLE PROPERTIES SOLUTION.
TOL = MAXIMUM ALLOWABLE CHANGE IN POPE PRESSURE BETWEEN
      ITERATIONS.
ITERMX = MAXIMUM NUMBER OF ITERATIONS IN SOLVE
DTMLIM = UPPER LIMIT ON TM TIME DURING A TIME DT
FCV=A REDUCTION FACTOR USED WHEN CHGMAX.GT.CHGLIM
CHGPMX=MAXIMUM ALLOWABLE CHANGE IN EFFECTIVE STRESS IN
SUBROUTINE CONSOL WITHOUT ITERATING FURTHER
PPLIM=A NUMBER SUCH THAT THE PROGRAM QUITS RUNNING WHEN ALL
      VALUES OF PP ARE LESS THAN THIS VALUE
ALMX1,ALMX2,ALMX3
=.5 .5 20.0
CHGMIN,CHGLIM,FCV
=.1 1.0 1.0
TOL,ITERMX,DTMLIM,CHGPMX,PPLIM
=.1 100 5.0 .1 .1
      KODPPR = C IF RESIDUAL POPE PRESSURES ARE ALL THE SAME
      = V IF RESIDUAL POPE PRESSURES ARE INPUT
      AT EACH DEPTH NODE
KODPPR
=C
PREPP,RESIDUAL POPE PRESSURE
=0.0
NFL = NUMBER OF CONSTRUCTION STAGES, MAY BE ZERO
TFCBEG(JF)=TIME FILL CONSTRUCTION BEGINS, DAYS
TFCEND(JF)=TIME FILL CONSTRUCTION ENDS, DAYS
TL(JL) =TIME WHEN FILL ELEVATION IS DEFINED, DAYS
EFL(JL) =ELEVATION OF THE TOP OF THE FILL RELATIVE TO THE TOP
      OF THE ORIGINAL GROUND SURFACE
GF(JF)=TOTAL UNIT WEIGHT OF FILL,PCF.
NFL
=1
TFCBEG,TFCEND,GF 1
=0.00 0. 112.4
TL,EFL 1
=0.0 0.0
TL,EFL 2
=0.0 20.0
TL,EFL 3
=5000.0 20.0
TL,EFL 4
=-1.0 0.0

```

(Continued)

Table 20 (Continued)

TO<J0>=TIMES FOR WHICH OUTPUT IS DESIRED
 IOUT<J0>=D FOR DETAILED OUTPUT AT TO<J0>-N FOR NONE
 OTDATA=D FOR OUTPUT OF DETAILED DATA AT THE LAST VALUE OF TO
 WHEN ALL PP<I> ARE LESS THAN PPLIM
 TO, IOUT 1
 =.1 D
 TO, IOUT 2
 =1.0 D
 TO, IOUT 3
 =4.0 N
 TO, IOUT 4
 =10. D
 TO, IOUT 5
 =40.0 N
 TO, IOUT 6
 =100.0 D
 TO, IOUT 7
 =400.0 N
 TO, IOUT 8
 =1000.0 D
 TO, IOUT 9
 =2000.0 D
 TO, IOUT 10
 =-1.0 N
 OTDATA
 =D
 MODORD=V FOR VOID RATIO DIAGRAMS
 =S FOR STRAIN DIAGRAMS
 MODINT=N INTERPOLATE P ARITHMETICALLY FOR E-P RELATIONSHIP
 =L INTERPOLATE P LOGARITHMICALLY FOR E-P RELATIONSHIP
 MODORD, MODINT
 =V N
 LAYER 1
 PE=EFFECTIVE STRESS, EP=VOID RATIO OR STRAIN, PIONT 1
 =0.00 1.000
 PE=EFFECTIVE STRESS, EP=VOID RATIO OR STRAIN, PIONT 2
 =10000.00 1.0000
 PE=EFFECTIVE STRESS, EP=VOID RATIO OR STRAIN, PIONT 3
 =-1.0 0.0
 CCP=SLOPE OF REBOUND CURVE
 =.00100
 LAYER 2
 PE=EFFECTIVE STRESS, EP=VOID RATIO OR STRAIN, PIONT 1
 =0.00 2.0075
 PE=EFFECTIVE STRESS, EP=VOID RATIO OR STRAIN, PIONT 2
 =2300.0 1.9500
 PE=EFFECTIVE STRESS, EP=VOID RATIO OR STRAIN, PIONT 3
 =-1.00 0.00
 CCP=SLOPE OF REBOUND CURVE
 =.00100
 CVID=A LIMIT SUCH THAT ANY LAYER WITH A HIGHER VALUE OF CV
 SHOULD BE A SAND LAYER.
 CVID
 =100.0

(Continued)

Table 20 (Concluded)

$\text{FODIP/L} = 0$ FOR CONSTANT CV AND PK VALUES
 $\text{FODIP/L} = V$ FOR CV AND PK FUNCTIONS OF EFFECTIVE STRESS
 $VP = \text{CONST}$ IF ALL LAYERS HAVE $\text{FODIP/L} = 0$
 $VP = \text{VAR}$ IF ANY LAYER HAS $\text{FODIP/L} = V$
 $\text{PEMVL,JCW} = \text{EFFECTIVE STRESS AT WHICH A POINT ON THE P-CV CURVE IS DEFINED FOR LAYER L AND POINT JCW, PEP}$
 $\text{CWP,L,JCW} = \text{COEFFICIENT OF CONSOLIDATION AT THE JCW POINT ON THE INPUT P-CV CURVE OF LAYER L (CO.FT./DAY)}$
 $\text{PP/L,JCW} = \text{COEFFICIENT OF PERMEABILITY AT THE JCW POINT ON THE INPUT P-PK CURVE OF LAYER L (FT./DAY)}$
 LAYER 1
 $= 0$
 CWP,PEP
 $= 200.0 \ 200.0$
 LAYER 2
 $= 0$
 CWP,PEP
 $= .05 \ .05$

Input Data File for Program FB31

(Example Problem 1)

```

100  SAMPLE PROBLEM NO. 1: FOR USING FB31-35
110  1 1 1 1 1 1 1 1
120  -20.0  -20.0  0  F J F T F
130  2
140  1.00  50.0  2
150  10.00  50.0  11
160  .5 .5 20.0
170  .10 1.00 1.0
180  .1 100 5.0 .1 .1
190  0
200  0.0
210  1
220  0.00  0.00  112.40
230  0.00  0.00
240  0.00  20.00
250  5000.00  20.00
260  -1.00  -0.00
270  .1 D
280  1.0 D
290  4.0
300  10.0 D
310  40.0
320  100.0 D
330  400.0
340  1000.0 D
350  2000.0 D
360  -1.0
370  D
380  V N
390  0.00  1.0000
400  10000.00  1.0000
410  -1.00  -1.0000
420  .00100
430  0.00  2.0075
440  2300.00  1.2500
450  -1.00  -0.0000
460  .00100
470  1.00E+02
480  0
490  2.00E+02 2.00E+02
500  0
510  5.00E-02 5.00E-02

```

- o. DTMLIM=5.0. The analysis will be aborted if the running time for any one value of time, TC, reaches 5 seconds.
- p. CHGPMX=0.1. The equation for effective stress at any node requires as input the value of surface settlement, but this is the settlement to be calculated. The sub-routine will iterate on the effective stresses until no effective stress changes by more than 0.1 lb/ft^2 during the final iteration.
- q. PPLIM=0.1. During the time period between TL(JLFIN-1) and TL(JLFIN), if all the excess pore pressures have absolute values smaller than 0.1 lb/ft^2 , the run will terminate.
- r. KODPPR=C. The initial excess pore pressures, prior to the beginning of the analysis, are constant; i.e., independent of depth.
- s. QTDATA=D. If the run is terminated because all pore pressures have absolute values smaller than PPLIM, then detailed data will be output at the final time of analysis.
- t. KODORD=V. The consolidation curve is defined using void ratios.
- u. KODINT=N. The linear $e-\bar{\sigma}$ curve is assumed between specific points that define this curve.
- v. KODSP=C. The coefficient of consolidation is constant.

Output

41. The complete output file is shown in Table 21. Note that values less than zero have been printed in the file of echo prints where no value was defined originally; e.g., when input of a set of data is terminated by use of a value -1.0 for the appropriate variable.

Comparison with Hand Solutions

42. With this simple example, a hand comparison can easily be made (Table 22). Olson and Ladd explore the comparison of classical and the finite difference analysis in more detail.

Table 21
Output Data File for Program FD31 Example Problem

CUP,PKP
 -.05 .05

EXAMPLE PROBLEM FOR SETTLEMENT PACKAGE

TABLE 1
 ORIGINAL LAYER CONDITIONS

LAYER NO.	ORIGINAL THICKNESS FEET	NUMBER OF NODES	SUBMERGED UNIT WEIGHT (PSF)
1	1.00	2	50.0
2	10.00	11	50.0

TABLE 2
 DATA ON WATER TABLE AND DRAINAGE
 THE WATER TABLE WILL REMAIN AT A CONSTANT ELEVATION WITH
 ZUTO = -30.0 FEET.

BOTH HORIZONTAL BOUNDARIES ARE FREELY DRAINING.

THE PROGRAM WILL TREAT ANY LAYER AS FREELY DRAINING IF
 CU.GE. 0.10E 03 50.FT.PER DAY.

STATIC PORE WATER PRESSURES ABOVE THE WATER TABLE ARE ASSUMED
 TO BE ZERO AT ALL TIMES.

ALL SAND LAYERS ARE ASSUMED TO DRAIN FREELY IN THE HORIZONTAL
 DIRECTION AND THUS HAVE ZERO EXCESS PORE PRESSURES AT ALL TIMES.

TABLE 3
 INITIAL EXCESS PORE PRESSURES

LAYER NO.	NODE NO.	PORE PRESSURE (PSF)
1	1	0.
1-2	2	0.
2	3	0.
2	4	0.
2	5	0.
2	6	0.
2	7	0.
2	8	0.
2	9	0.
2	10	0.
2	11	0.
2	12	0.

(Continued)

Table 21 (Continued)

TABLE 4
LOAD HISTORY

FILL LAYER NUMBER	TOTAL UNIT WEIGHT (PCF)	TIME FILL CONSTRUCTION BEGINS (DAYS)	TIME FILL CONSTRUCTION ENDS (DAYS)
1	112.4	0.	0.

TIME (DAYS)	EMBANKMENT HEIGHT (FT)
0.	0.
0.	20.00
5000.	20.00

TABLE 5
TIMES FOR OUTPUT

0.1 DAYS
1.0 DAYS
4.0 DAYS
10.0 DAYS
40.0 DAYS
100.0 DAYS
400.0 DAYS
1000.0 DAYS
2000.0 DAYS

(Continued)

Table 21 (Continued)

TABLE 6

E - P C U R V E S

LAYER	EFFECTIVE STRESS (PSF)	VOID RATIO
1	0.	1.0000
	10000.0	1.0000
2	0.	2.0075
	2300.0	1.9500

LAYER	SLOPE OF REBOUND E - LOG P CURVE
1	0.1E-02
2	0.1E-02

VALUES OF E ARE FOUND BY INTERPOLATING
E AND P NATURALLY.

TABLE 7

TABLE OF INPUT VALUES OF CU AND PK

LAYER NO.	EFFECTIVE STRESS PSF	COEFF.OF CONSOLIDATION SQ.FT/DAY	COEFF.OF PERMEABILITY FT/DAY
1	NOT INPUT	0.20E 03	0.20E 03
2	NOT INPUT	0.50E-01	0.50E-01

(Continued)

Table 21 (Continued)

TABLE 9

TABLE OF CONTROL PARAMETERS

THE MAXIMUM VALUES OF ALPHA ARE LIMITED TO 0.5 DURING LOADING OR UNLOADING, TO 0.5 FOR ANY NON-LOADING PERIOD EXCEPT THE LAST ONE AND TO BETWEEN 0.5 AND 20.0 DURING THE LAST LOADING PERIOD.

THE GAUS-SEIDEL ITERATIONS WILL CONTINUE UNTIL NO PORE PRESSURE CHANGES BY MORE THAN 0.10 PSF FROM ONE ITERATION TO THE NEXT BUT THE ANALYSIS WILL TERMINATE IF 100 ITERATIONS ARE PERFORMED FOR ANY ONE SET OF PORE PRESSURE CALCULATIONS.

IF THE TM TIME USED BETWEEN ONE OUTPUT TIME AND THE NEXT EXCEEDS 5.0 SECONDS, THE ANALYSIS IS TERMINATED AFTER OUTPUTTING THE DATA.

IN SUBROUTINE CONSOL, THE PROGRAM ITERATES ON THE EFFECTIVE STRESS EQUATION UNTIL NO VALUE OF P(I) CHANGES BY MORE THAN 0.10 PSF. THE NUMBER OF SUCH ITERATIONS IS OUTPUT AS CHGP.

IF THE MAXIMUM FRACTIONAL CHANGE IN ANY VALUE OF CU EXCEEDS 1.0 (OR IS LESS THAN THE RECIPROCAL OF THIS NUMBER FOR DECREASING VALUES OF CU) THEN THE PROGRAM REDUCES THE TIME STEP TO DT-DT*0.9*CHGLIN/CHGMAX AND STARTS ON A NEW SET OF CALCULATIONS. FOR THIS PROBLEM FCU=1.0 IF THE MAXIMUM FRACTIONAL CHANGE IN CU IS LESS THAN 0.1 THEN THE ANALYSIS DOES NOT CYCLE BACK. IF THE MAXIMUM FRACTIONAL CHANGE IS BETWEEN 0.1 AND 1.0 A SET OF AVERAGE CU VALUES ARE CALCULATED AND THE CALCULATIONS ARE REPEATED.

TABLE 10

INITIAL CONDITIONS

LAYER NO.	NODE NO.	Z(I) PSF	SIGNSO(I) PSF	STATPP(I) PSF	PREPP(I) PSF	P(I) PSF	S(I) FT
1	1	0.	0.	1872.00	0.	0.	0.
1-2	2	1.000	112.40	1934.40	0.	50.00	0.
	3	2.000	224.80	1996.80	0.	100.00	0.
2	4	3.000	337.20	2059.20	0.	150.00	0.
2	5	4.000	449.60	2121.60	0.	200.00	0.
2	6	5.000	562.00	2184.00	0.	250.00	0.
2	7	6.000	674.40	2246.40	0.	300.00	0.
2	8	7.000	786.80	2308.80	0.	350.00	0.
2	9	8.000	899.20	2371.20	0.	400.00	0.
2	10	9.000	1011.60	2433.60	0.	450.00	0.
2	11	10.000	1124.00	2496.00	0.	500.00	0.
2-3	12	11.000	1236.40	2558.40	0.	550.00	0.

LAYER NO.	IN NO.	ZIN(IN) FT.	PIN(IN) PSF	EO(IN)	CU(IN)	PK(IN)	DZ(IN) FT.	DZO(IN) FT.
1	1	0.500	25.00	1.0000	0.200E-03	0.200E-03	1.000	0.5000
2	2	1.500	75.00	2.0056	0.500E-01	0.500E-01	1.000	0.3327
2	3	2.500	125.00	2.0044	0.500E-01	0.500E-01	1.000	0.3328
2	4	3.500	175.00	2.0031	0.500E-01	0.500E-01	1.000	0.3330
2	5	4.500	225.00	2.0019	0.500E-01	0.500E-01	1.000	0.3331
2	6	5.500	275.00	2.0006	0.500E-01	0.500E-01	1.000	0.3333
2	7	6.500	325.00	1.9994	0.500E-01	0.500E-01	1.000	0.3334
2	8	7.500	375.00	1.9981	0.500E-01	0.500E-01	1.000	0.3335
2	9	8.500	425.00	1.9969	0.500E-01	0.500E-01	1.000	0.3337
2	10	9.500	475.00	1.9956	0.500E-01	0.500E-01	1.000	0.3338
2	11	10.500	525.00	1.9944	0.500E-01	0.500E-01	1.000	0.3340

(Continued)

Table 21 (Continued)

TABLE 11

SOLUTION INFORMATION

TIME (DAYS) = 0.1
 TIME STEP(DAYS) = 0.1
 LOAD Q (PSF) = 2248.00
 ELEVATION OF WATER TABLE (FT.) = 30.0
 ELEVATION OF TOP OF FILL (FEET) = 19.99
 NUMBER OF ITERATIONS = 2
 UPPER LIMIT ON ALPHA = 0.500
 MAXIMUM DEVELOPED ALPHA = 0.005
 SIGFW (PSF) = 624.5
 NO. OF CYCLES THRU COEFF = 1
 TM TIME (SECONDS) = 0.014
 CHGP (PSF) = 0.000
 MP = 1

LAYER NO.	NODE NO.	DEPTH FT.	TOTAL STRESS PSF	TOTAL PP PSF	EXCESS PP PSF	EFF. STRESS PSF	SETTLEMENT FT.
1	1	0.000	2872.5	1872.5	0.	1000.0	0.000
1-2	2	1.000	2984.9	1934.9	0.	1050.0	0.000
2	3	2.004	3097.1	2992.1	995.0	105.0	0.004
2	4	3.004	3209.5	3059.5	1000.0	150.0	0.004
2	5	4.004	3321.9	3121.9	1000.0	200.0	0.004
2	6	5.004	3434.3	3184.3	1000.0	250.0	0.004
2	7	6.004	3546.7	3246.7	1000.0	300.0	0.004
2	8	7.004	3659.1	3309.1	1000.0	350.0	0.004
2	9	8.004	3771.5	3371.5	1000.0	400.0	0.004
2	10	9.004	3883.9	3433.9	1000.0	450.0	0.004
2	11	10.004	3996.3	3491.3	995.0	505.0	0.004
2	12	11.000	4108.4	2558.4	0.	1550.0	0.

L, IN	DEPTH FT.	EFF. STRESS PSF	VOID RATIO	CU SQ.FT/DAY	CUNEU SQ.FT/DAY	K FT/DAY	ALPHA	PM PSF	DZ FT.
1	1	0.51	1025.0	1.000	0.0500	0.20E 03	20.000	1025.0	1.000
2	2	1.51	577.5	1.993	0.0500	0.50E-01	0.005	577.5	0.994
2	3	2.50	127.5	2.004	0.0500	0.50E-01	0.005	127.5	1.000
2	4	3.50	175.0	2.003	0.0500	0.50E-01	0.005	175.0	1.000
2	5	4.50	225.0	2.002	0.0500	0.50E-01	0.005	225.0	1.000
2	6	5.50	275.0	2.001	0.0500	0.50E-01	0.005	275.0	1.000
2	7	6.50	325.0	1.999	0.0500	0.50E-01	0.005	325.0	1.000
2	8	7.50	375.0	1.998	0.0500	0.50E-01	0.005	375.0	1.000
2	9	8.50	425.0	1.997	0.0500	0.50E-01	0.005	425.0	1.000
2	10	9.50	477.5	1.996	0.0500	0.50E-01	0.005	477.5	1.000
2	11	10.50	1027.5	1.982	0.0500	0.50E-01	0.005	1027.5	0.996

LAYER NO.	COMPRESSION (INCHES)
1	-0.0000
2	0.1010

(Continued)

Table 21 (Continued)

TABLE 11
SOLUTION INFORMATION

TIME (DAYS) = 1.0
 TIME STEP(DAYS) = 0.9
 LOAD Q (PSF) = 2248.00
 ELEVATION OF WATER TABLE (FT.) = 30.0
 ELEVATION OF TOP OF FILL (FEET) = 19.99
 NUMBER OF ITERATIONS = 3
 UPPER LIMIT ON ALPHA = 0.500
 MAXIMUM DEVELOPED ALPHA = 0.045
 SIGFU (PSF) = 624.6
 NO. OF CYCLES THRU COEFF = 1
 TM TIME (SECONDS) = 0.271
 CHGP (PSF) = -0.000
 MP = 1

LAYER NO.	NODE NO.	DEPTH FT.	TOTAL STRESS PSF	TOTAL PP PSF	EXCESS PP PSF	EFF. STRESS PSF	SETTLEMENT FT
1	1	0.009	2872.6	1872.6	0.	1000.0	0.009
1-2	2	1.009	2985.0	1935.0	0.	1050.0	0.009
2	3	2.005	3097.1	2949.2	952.1	147.9	0.005
2	4	3.005	3209.5	3058.3	998.8	151.2	0.005
2	5	4.005	3321.9	3121.9	1000.0	200.0	0.005
2	6	5.005	3434.3	3184.3	1000.0	250.0	0.005
2	7	6.005	3546.7	3246.7	1000.0	300.0	0.005
2	8	7.005	3659.1	3309.1	1000.0	350.0	0.005
2	9	8.005	3771.5	3371.5	1000.0	400.0	0.005
2	10	9.005	3883.9	3432.7	998.8	451.2	0.005
2	11	10.004	3996.3	3448.4	952.1	547.9	0.004
2	12	11.000	4108.4	2558.4	0.	1550.0	0.

L, IN	DEPTH FT.	EFF. STRESS PSF	VOID RATIO	CU SQ.FT/ DAY	CUNEW SQ.FT/ DAY	K FT/DAY	ALPHA	PM PSF	DZ FT.
1 1	0.51	1025.0	1.000	0.0500	0.0500	0.20E 03	180.000	1025.0	1.000
2 2	1.51	598.9	1.993	0.0500	0.0500	0.50E-01	0.045	598.9	0.996
2 3	2.50	149.5	2.004	0.0500	0.0500	0.50E-01	0.045	149.5	1.000
2 4	3.50	175.6	2.003	0.0500	0.0500	0.50E-01	0.045	175.6	1.000
2 5	4.50	225.0	2.002	0.0500	0.0500	0.50E-01	0.045	225.0	1.000
2 6	5.50	275.0	2.001	0.0500	0.0500	0.50E-01	0.045	275.0	1.000
2 7	6.50	325.0	1.999	0.0500	0.0500	0.50E-01	0.045	325.0	1.000
2 8	7.50	375.0	1.998	0.0500	0.0500	0.50E-01	0.045	375.0	1.000
2 9	8.50	425.6	1.997	0.0500	0.0500	0.50E-01	0.045	425.6	1.000
2 10	9.50	499.5	1.995	0.0500	0.0500	0.50E-01	0.045	499.5	1.000
2 11	10.50	1048.9	1.981	0.0500	0.0500	0.50E-01	0.045	1048.9	0.996

LAYER COMPRESSION
 NO. (INCHES)
 1 0.0000
 2 0.1098

(Continued)

Table 21 (Continued)

TABLE 11
SOLUTION INFORMATION

TIME (DAYS) = 10.0
 TIME STEP(DAYS) = 6.0
 LOAD Q (PSF) = 2248.00
 ELEVATION OF WATER TABLE (FT.) = 30.0
 ELEVATION OF TOP OF FILL (FEET) = 19.98
 NUMBER OF ITERATIONS = 5
 UPPER LIMIT ON ALPHA = 0.516
 MAXIMUM DEVELOPED ALPHA = 0.303
 SIGFW (PSF) = 624.9
 NO. OF CYCLES THRU COEFF = 1
 TM TIME (SECONDS) = 0.013
 CHGP (PSF) = 0.000
 MP = 1

LAYER NO.	NODE NO.	DEPTH FT.	TOTAL STRESS PSF	TOTAL PP PSF	EXCESS PP PSF	EFF. STRESS PSF	SETTLEMENT FT.
1	1	0.015	2872.9	1872.9	0.	1000.0	0.015
1-2	2	1.015	2985.3	1935.3	0.	1050.0	0.015
2	3	2.010	3097.4	2665.7	668.3	431.7	0.010
2	4	3.008	3209.7	2992.7	933.0	217.0	0.008
2	5	4.008	3322.1	3111.9	989.8	210.2	0.008
2	6	5.008	3434.5	3183.1	998.6	251.4	0.008
2	7	6.008	3546.9	3246.5	999.7	300.3	0.008
2	8	7.008	3659.3	3307.9	998.6	351.4	0.008
2	9	8.008	3771.7	3361.5	989.8	410.2	0.008
2	10	9.007	3884.1	3367.0	933.0	517.0	0.007
2	11	10.006	3996.3	3164.7	668.3	831.7	0.006
2	12	11.000	4108.4	2558.4	0.	1550.0	0.

L, IN	DEPTH FT.	EFF. STRESS PSF	VOID RATIO	CU SQ.FT./DAY	CUNEU SQ.FT./DAY	K FT/DAY	ALPHA	PM PSF	DZ FT.
1 1	0.52	1025.0	1.000	0.0500	0.0500	0.20E-03	0.303	1025.0	1.000
2 2	1.51	740.8	1.989	0.0500	0.0500	0.50E-01	0.303	740.8	0.994
2 3	2.51	324.3	1.999	0.0500	0.0500	0.50E-01	0.300	324.3	0.998
2 4	3.51	213.6	2.002	0.0500	0.0500	0.50E-01	0.300	213.6	1.000
2 5	4.51	230.8	2.002	0.0500	0.0500	0.50E-01	0.300	230.8	1.000
2 6	5.51	275.9	2.001	0.0500	0.0500	0.50E-01	0.300	275.9	1.000
2 7	6.51	325.9	1.999	0.0500	0.0500	0.50E-01	0.300	325.9	1.000
2 8	7.51	380.8	1.998	0.0500	0.0500	0.50E-01	0.300	380.8	1.000
2 9	8.51	463.6	1.996	0.0500	0.0500	0.50E-01	0.300	463.6	1.000
2 10	9.51	674.3	1.991	0.0500	0.0500	0.50E-01	0.300	674.3	0.998
2 11	10.50	1190.8	1.978	0.0500	0.0500	0.50E-01	0.303	1190.8	0.994

LAYER COMPRESSION
 NO. (INCHES)

1	0.0000
2	0.1821

(Continued)

Table 21 (Continued)

TABLE 11

SOLUTION INFORMATION

TIME (DAYS) - 100.0
 TIME STEP(DAYS) - 2.0
 LOAD Q (PSF) - 2248.00
 ELEVATION OF WATER TABLE (FT.) - 30.0
 ELEVATION OF TOP OF FILL (FEET) - 19.96
 NUMBER OF ITERATIONS - 3
 UPPER LIMIT ON ALPHA - 0.882
 MAXIMUM DEVELOPED ALPHA - 0.100
 SIGFM (PSF) - 626.7
 NO. OF CYCLES THRU COEFF - 5
 TM TIME (SECONDS) - 0.065
 CHGP (PSF) - 0.000
 MP - 1

LAYER NO.	NODE NO.	DEPTH FT.	TOTAL STRESS PSF	TOTAL PP PSF	EXCESS PP PSF	EFF. STRESS PSF	SETTLEMENT FT
1	1	0.043	2874.7	1874.7	0.	1000.0	0.043
1-2	2	1.043	2987.1	1937.1	0.	1050.0	0.043
2	3	2.035	3099.0	2241.3	242.3	857.7	0.035
2	4	3.030	3211.1	2519.3	458.2	691.8	0.030
2	5	4.026	3323.2	2749.0	625.7	574.3	0.026
2	6	5.023	3435.5	2916.2	730.7	519.3	0.023
2	7	6.021	3547.7	3014.1	766.4	533.6	0.021
2	8	7.019	3660.0	3040.7	730.7	619.3	0.019
2	9	8.017	3772.2	2997.9	625.7	774.3	0.017
2	10	9.013	3884.4	2892.5	458.1	991.9	0.013
2	11	10.007	3996.5	2738.7	242.3	1257.7	0.007
2	12	11.000	4108.4	2558.4	0.	1550.0	0.

L, IN	DEPTH FT.	EFF. STRESS PSF	CU VOID RATIO	CU SQ.FT./DAY	CUNEW SQ.FT./DAY	K FT/DAY	ALPHA	PM PSF	DZ FT.
1 1	0.54	1025.0	1.000	0.0500	0.0500	0.20E 03394.248	0.100	1025.0	1.000
2 2	1.54	953.8	1.984	0.0500	0.0500	0.50E-01	0.100	953.8	0.993
2 3	2.53	774.7	1.988	0.0500	0.0500	0.50E-01	0.100	774.7	0.995
2 4	3.53	633.0	1.992	0.0500	0.0500	0.50E-01	0.099	633.0	0.996
2 5	4.52	546.8	1.994	0.0500	0.0500	0.50E-01	0.099	546.8	0.997
2 6	5.52	526.5	1.994	0.0500	0.0500	0.50E-01	0.099	526.5	0.998
2 7	6.52	576.5	1.993	0.0500	0.0500	0.50E-01	0.099	576.5	0.998
2 8	7.52	696.8	1.990	0.0500	0.0500	0.50E-01	0.099	696.8	0.997
2 9	8.51	883.1	1.985	0.0500	0.0500	0.50E-01	0.099	883.1	0.996
2 10	9.51	1124.8	1.979	0.0500	0.0500	0.50E-01	0.100	1124.8	0.995
2 11	10.50	1403.9	1.972	0.0500	0.0500	0.50E-01	0.100	1403.9	0.993

LAYER NO.	COMPRESSION (INCHES)
1	0.0000
2	0.5120

(Continued)

Table 21 (Continued)

TABLE 11
SOLUTION INFORMATION

TIME (DAYS) = 1000.0
 TIME STEP(DAYS) = 22.0
 LOAD Q (PSF) = 2248.00
 ELEVATION OF WATER TABLE (FT.) = 30.0
 ELEVATION OF TOP OF FILL (FEET) = 19.92
 NUMBER OF ITERATIONS = 3
 UPPER LIMIT ON ALPHA = 4.314
 MAXIMUM DEVELOPED ALPHA = 1.120
 SIGFU (PSF) = 629.2
 NO. OF CYCLES THRU COEFF = 11
 TM TIME (SECONDS) = 0.154
 CHGP (PSF) = -0.000
 MP = 1

LAYER NO.	NODE NO.	DEPTH FT.	TOTAL STRESS PSF	TOTAL PP PSF	EXCESS PP PSF	EFF. STRESS PSF	SETTLEMENT FT
1	1	0.083	2877.2	1877.2	0.	1000.0	0.083
1-2	2	1.083	2989.6	1939.6	0.	1050.0	0.083
2	3	2.075	3101.5	2004.2	2.8	1097.2	0.075
2	4	3.066	3213.3	2068.6	5.3	1144.7	0.066
2	5	4.058	3325.2	2132.4	7.2	1192.8	0.058
2	6	5.050	3437.1	2195.6	8.4	1241.6	0.050
2	7	6.041	3549.0	2257.8	8.9	1291.1	0.041
2	8	7.033	3660.9	2319.3	8.4	1341.6	0.033
2	9	8.025	3772.8	2379.9	7.1	1392.9	0.025
2	10	9.017	3884.6	2439.8	5.2	1444.8	0.017
2	11	10.008	3996.5	2499.2	2.7	1497.3	0.008
2	12	11.000	4108.4	2558.4	0.	1550.0	0.

L, IN	DEPTH FT.	EFF. STRESS PSF	VOID RATIO	CU SQ.FT./DAY	CUNEW SQ.FT./DAY	K FT/DAY	ALPHA	PM PSF	DZ FT.
1 1	0.58	1025.0	1.000	0.0500	0.0500	0.20E 03	0.03	1025.0	1.000
2 2	1.58	1073.6	1.981	0.0500	0.0500	0.50E-01	1.120	1073.6	0.992
2 3	2.57	1121.0	1.979	0.0500	0.0500	0.50E-01	1.120	1121.0	0.992
2 4	3.56	1168.8	1.978	0.0500	0.0500	0.50E-01	1.120	1168.8	0.992
2 5	4.55	1217.2	1.977	0.0500	0.0500	0.50E-01	1.120	1217.2	0.992
2 6	5.55	1266.3	1.976	0.0500	0.0500	0.50E-01	1.120	1266.3	0.992
2 7	6.54	1316.4	1.975	0.0500	0.0500	0.50E-01	1.120	1316.4	0.992
2 8	7.53	1367.2	1.973	0.0500	0.0500	0.50E-01	1.120	1367.2	0.992
2 9	8.52	1418.9	1.972	0.0500	0.0500	0.50E-01	1.120	1418.9	0.992
2 10	9.51	1471.1	1.971	0.0500	0.0500	0.50E-01	1.120	1471.1	0.992
2 11	10.50	1523.6	1.969	0.0500	0.0500	0.50E-01	1.120	1523.6	0.992

LAYER COMPRESSION
 NO. (INCHES)
 1 0.0000
 2 0.9944

(Continued)

Table 21 (Continued)

TABLE 11
SOLUTION INFORMATION

TIME (DAYS) = 2000.0
 TIME STEP(DAYS) = 90.4
 LOAD Q (PSF) = 2248.00
 ELEVATION OF WATER TABLE (FT.) = 30.0
 ELEVATION OF TOP OF FILL (FEET) = 19.92
 NUMBER OF ITERATIONS = 1
 UPPER LIMIT ON ALPHA = 7.947
 MAXIMUM DEVELOPED ALPHA = 4.598
 SIGFY (PSF) = 629.2
 NO. OF CYCLES THRU COEFF = 9
 TM TIME (SECONDS) = 0.373
 CMGP (PSF) = -0.000
 MP = 1

LAYER NO.	NODE NO.	DEPTH FT.	TOTAL STRESS PSF	TOTAL PP PSF	EXCESS PP PSF	EFF. STRESS PSF	SETTLEMENT FT
1	1	0.083	2877.2	1877.2	0.	1000.0	0.083
1-2	2	1.083	2989.6	1939.6	0.	1050.0	0.083
2	3	2.075	3101.5	2001.6	0.1	1099.9	0.075
2	4	3.067	3213.4	2063.6	0.3	1149.7	0.067
2	5	4.058	3325.2	2125.6	0.4	1199.6	0.058
2	6	5.050	3437.1	2187.5	0.4	1249.6	0.050
2	7	6.042	3549.0	2249.4	0.4	1299.6	0.042
2	8	7.033	3660.9	2311.3	0.4	1349.6	0.033
2	9	8.025	3772.8	2373.1	0.3	1399.7	0.025
2	10	9.017	3884.6	2434.9	0.2	1449.8	0.017
2	11	10.008	3996.5	2496.6	0.1	1499.9	0.008
2	12	11.000	4108.4	2558.4	0.	1550.0	0.

L, IN	DEPTH FT.	EFF. STRESS PSF	VOID RATIO	CU SQ.FT./ DAY	CUNEU SQ.FT./ DAY	K FT/DAY	ALPHA	PM PSF	DZ FT.
1	1	0.58	1025.0	1.000	0.0500	0.20E 03	0.03	1025.0	1.000
2	2	1.58	1074.9	1.981	0.0500	0.50E-01	4.597	1074.9	0.992
2	3	2.57	1124.8	1.979	0.0500	0.50E-01	4.597	1124.8	0.992
2	4	3.56	1174.7	1.978	0.0500	0.50E-01	4.597	1174.7	0.992
2	5	4.55	1224.6	1.977	0.0500	0.50E-01	4.597	1224.6	0.992
2	6	5.55	1274.6	1.976	0.0500	0.50E-01	4.597	1274.6	0.992
2	7	6.54	1324.6	1.974	0.0500	0.50E-01	4.598	1324.6	0.992
2	8	7.53	1374.7	1.973	0.0500	0.50E-01	4.598	1374.7	0.992
2	9	8.52	1424.7	1.972	0.0500	0.50E-01	4.598	1424.7	0.992
2	10	9.51	1474.8	1.971	0.0500	0.50E-01	4.598	1474.8	0.992
2	11	10.50	1524.9	1.969	0.0500	0.50E-01	4.598	1524.9	0.992

LAYER COMPRESSION
 NO. (INCHES)

1	0.0000
2	0.9997

(Continued)

Table 21 (Concluded)

TABLE 12
SUMMARY OF TIME SETTLEMENT DATA

TIME (DAYS)	SETTLEMENT (FEET)	DEGREE OF CONSOLIDATION (PERCENT)
0.1	0.00842	10.1
1.0	0.00915	11.0
4.0	0.01140	13.7
10.0	0.01517	18.2
40.0	0.02757	33.1
100.0	0.04267	51.2
400.0	0.07417	89.0
1000.0	0.08287	99.5
2000.0	0.08331	100.0

2

Table 22
Comparison of FD31 and Hand Solutions for
Settlement and Degree of Consolidation

<u>Settlement, ft</u>		
<u>FD31 Solution</u>		<u>Hand Solution</u>
0.08331		0.083

<u>Time days</u>	<u>Degree of Consolidation percent</u>	
	<u>FD31 Solution</u>	<u>Hand Solution</u>
0.1	10.1	3
1.0	11.0	5
4.0	13.7	10
10.0	18.2	16
40.0	33.1	32
100.0	51.2	51
400.0	84.0	88
1000.0	99.5	99
2000.0	100.0	100

REFERENCES

Headquarters, Department of the Army, Office of the Chief of Engineers. 1953. "Soil Mechanics Design, Settlement Analysis," Engineering Manual 1110-2-1904, Washington, D. C.

Olson, R. E. "Analysis of One-Dimensional Consolidation Problems with Emphasis on Program FD31," University of Texas, Austin, Tex.; Program No. 741-F3-RO-105, CORPS Library, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Olson, R. E. and Ladd, C. C. "Analysis of One-Dimensional Consolidation Problems," Submitted to the Journal of the Geotechnical Engineering Division, ASCE.

Schiffman, R. L., Jubenville, D. M., and Partyka, V. 1976. "Magset-II, Version 1-A, a Computer Program to Calculate the Magnitude of Settlement of a Multi-Layered Soil System, User's Manual," GESA Report No. D-76-9, Geotechnical Engineering Software Activity, University of Colorado Computing Center, Boulder, Colo.; Program No. 741-F3-RO-105, CORPS Library, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

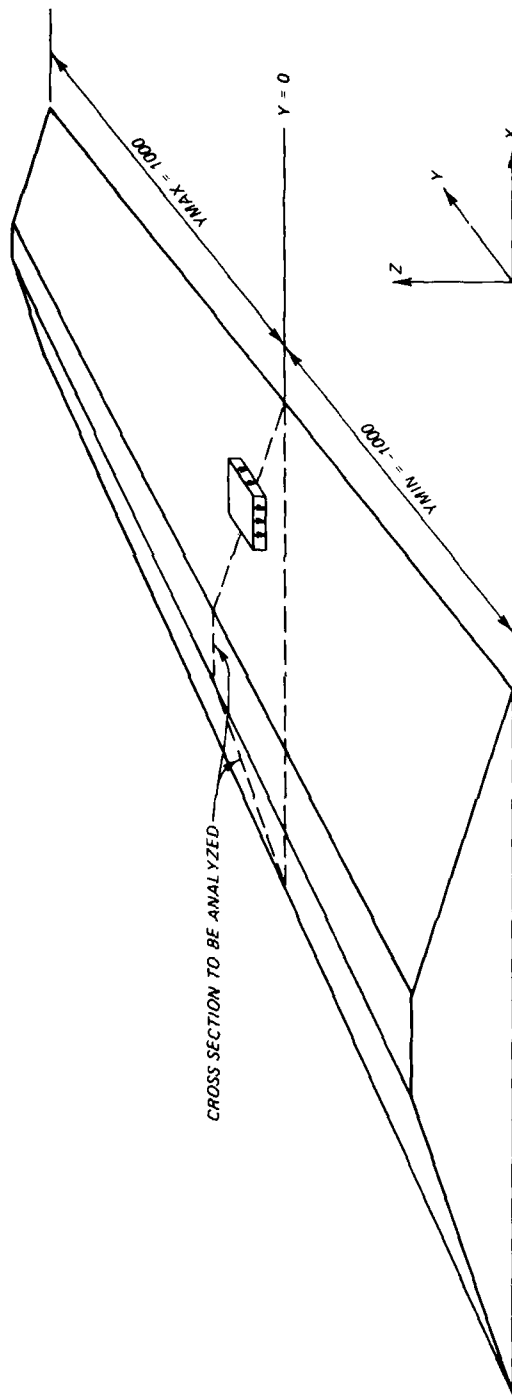
Spaulding, D. 1968. "I0016, Vertical Stresses Beneath Embankment and Footing Loadings," No. 741-GI-F5010, CORPS Library, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

APPENDIX A: INPUT FOR EMBANKMENT LOADS---PROGRAM I0016

1. This appendix describes the additional input data for program I0016 that are required to analyze the vertical stress in the foundation beneath an embankment. Following the lines describing the loaded rectangular ares (if any) is a set of lines describing the shape and weight of the embankment loading (see Figures A1 and A2). These lines will be necessary only under the option where KODE is input as 2 or 3. The first line required to describe the embankment consists of the following input variables (see line 430 in Table A1):

- a. NCOR. NCOR is the number of pairs of X and Y coordinates used to describe the cross section of the embankment loading. The maximum allowable value of NCOR is 25.
- b. GAMMA. The variable GAMMA is the unit weight of the embankment fill in units of weight and length compatible with the other input data.
- c. THICK. THICK is the input variable which determines the number of layers used to approximate the embankment loadings. THICK represents the maximum allowable thickness of any layer used in the approximation of the embankment loading.
- d. YMAX. The value of YMAX is the longitudinal distance from the cross section to the end of the embankment in the positive Y direction. YMAX should in all cases be greater than or equal to zero, since the cross section (X-Z plane) defining the embankment loading is assumed to be at $Y = 0$.
- e. YMIN. The value of YMIN is the longitudinal distance from the cross section to the end of the embankment in the negative Y direction. YMIN should in all cases be less than or equal to zero since the cross section (X-Z plane) defining the embankment loading is assumed to be at $Y = 0$.

2. The remaining cards required to describe the embankment loading consist of a series of lines each defining a pair of corner points (X,Z) of the embankment cross section. The number of these lines will correspond to the value of NCOR described above. These corner point lines should be input in the same sequence as they appear in the embankment cross section (see Figure A2). In other words, the input sequence should be the same as would be found by proceeding around the perimeter of the embankment cross section in either a clockwise or a counterclockwise



NOTE: SEE NEXT FIGURE FOR DETAILED
INPUT FOR CROSS SECTION

Figure A1. Embankment for input description

Table A1
Input for I0016

♦LIST NEWDAT

100 TEST DATA
 200 EMBANKMENT WITH 2 FOOTING LOADS
 300 FOOTING LOAD = 10,000 PSF, EMBK. UNIT WT. = 100 PCF
 350 1 VERTICAL STRESS DISTRIBUTION
 375 3 JAN. 1972, D.A.S.
 400 3 2
 410 10000.0 10.0 -40.0 5.0 -40.0 -5.0 -30.0 -5.0 30.0 5.0
 420 10000.0 10.0 30.0 -5.0 30.0 5.0 40.0 5.0 40.0 -5.0
 430 4 100.0 2.0 1000.0 -1000.0
 440 -70.0 0.0
 450 -10.0 20.0
 460 10.0 20.0
 470 70.0 0.0
 480 1 1 0.0
 490 20.0 40.0 2.0 0.0 0.0 0.0 0.0 0.0
 500 0 0 0.0

READY

♦

(Continued)

Table A1 (Concluded)

DO YOU WISH TO RUN PROGRAM FROM EXISTING DATA FILE?
 =YES
 FILE DESCRIPTION (47 CHARACTERS MAX), TYPE ? FOR INFO ON FORM
 =NEWDAT
 DO YOU WANT OUTPUT WRITTEN TO AN OUTPUT FILE?
 =YES
 FILE DESCRIPTION (47 CHARACTERS MAX), TYPE ? FOR INFO ON FORM
 =AUG2

◆LIST AUG2

TEST DATA
 EMBANKMENT WITH 2 FOOTING LOADS
 FOOTING LOAD = 10,000 PSF, EMBK. UNIT WT. = 100 PCF
 1 VERTICAL STRESS DISTRIBUTION
 3 JAN. 1972, D.A.S.

BOUSSINESQ SOLUTION

VERTICAL STRESS DISTRIBUTION AT
 X-COORDINATE = 0. Y-COORDINATE = 0.

DEPTH(Z)	ELASTIC SOLUTION VERTICAL STRESS	NORMAL LOADING VERTICAL STRESS
20.00	2682.575	3363.874
22.00	2588.604	3203.327
24.00	2501.253	3061.084
26.00	2419.576	2933.351
28.00	2342.841	2817.387
30.00	2270.469	2710.926
32.00	2201.999	2612.577
34.00	2137.057	2521.084
36.00	2075.333	2435.524
38.00	2016.567	2355.174
40.00	1960.537	2279.459

NUMBER OF AREAS USED IN CALCULATION = 13

NOTE-ALL Z VALUES ARE REFERENCED TO THE LOWEST PART OF THE INPUT,
 CONFIGURATION.

READY

AD-A093 955

ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS
COMPUTER PROGRAMS FOR SETTLEMENT ANALYSIS.(U)
OCT 80 R L MOSHER, N RADHAKRISHNAN
WES-ISTRUCTION-K-80-5

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direction. The lines required for each corner point will have a format described as follows (see lines 440-470 in Table A1):

- a. X(I). X(I) is the X coordinate of a corner (break point) in the shape of the embankment cross section.
- b. Z(I). Z(I) is the Z coordinate of a corner (break point) in the shape of the embankment cross section. The Z coordinates are referenced to the lowest Z coordinate which has a value of zero.

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.

Mosher, Reed L

Computer programs for settlement analysis / by Reed L. Mosher and N. Radhakrishnan. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1980.

87, 6 p. : ill. ; 27 cm. (Instruction report - U. S. Army Engineer Waterways Experiment Station ; K-80-5)

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

References: p. 87.

1. Cohesive soils. 2. Computer programs. 3. Embankments. 4. Foundation settlement. 5. Load tests (Foundations). 6. Settlement. 7. Settlement analysis. 8. Time settlement relationship. I. Radhakrishnan, Narayanswamy, joint author. II. United States. Army. Corps of Engineers. Lower Mississippi Valley Division. III. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Instruction report ; K-80-5.

TA7.W34i no.K-80-5

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