I0010

Geotechnical Engineering Software Activity
University of Colorado Computing Center
Boulder, Colorado

MAGSET-II
Version 1-A

A COMPUTER PROGRAM TO CALCULATE THE MAGNITUDE OF SETTLEMENT OF A MULTI-LAYERED SOIL SYSTEM

- USER'S MANUAL -

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GESA Report Number D-76-9

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University of Colorado Computing Center
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MAINTENANCE RECORD

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MAGSET	Program	N/A	EØ2-ØØØ4-ØØØ16

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9/76	MAGSET-II developed by V. Partyka, D.M. Jubenville, R.L. Schiffman, Geotechnical Engineering Software Activity, University of Colorado, Boulder, Colorado, 80309 Coded by: V. Partyka	Original Program

MAINTENANCE RECORD

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MAGSET	Documentation	D-76-9	E02-0004-00016

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9/76	"MAGSET-II, A Computer Program to Calculate the Magnitude of Settlement of a Multi-Layered Soil System, User's Manual", V. Partyka, D.M. Jubenville, R.L. Schiffman, Geotechnical Engineering Software Activity, University of Colorado, Boulder, Colorado, 80309	Original Program User's Manual

MAINTENANCE RECORD

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MAGSET	Documentation	D-76-10	EØ2-ØØØ4-ØØ016

05. DATE	06. DESCRIPTION	07. IDENTIFICATION
9/76	"MAGSET-II, A Computer Program to Calculate the Magnitude of Settlement of a Multi-Layered Soil System, Reference Documentation", V. Partyka, Geotechnical Engineering Software Activity, University of Colorado, Boulder, Colorado, 80309	Original Program Reference Documentation

IMPLEMENTATION RECORD

01. NAME	02. GENUS	03. VERSION	04. LEVEL	05. GESA NUMBER
MAGSET	II	1	A	EØ2-ØØØ4-ØØØ16

06. DESCRIPTION

MAGSET-II is a computer program to calculate the magnitude of settlement of a multi-layered soil profile containing cohesive and/or granular layers.

07. HARDWARE	08. LOCATION	09. IMPLEMENTATION DATE
CDC 6400	University of Colorado Computing Center Boulder, Colorado 80309	1 September 1976
10. CHARACTER CODE	**11. CONTROL LANGUAGE**	**12. COMPILER**
BCD	KCL	RUN, FTN
13. OPERATING SYSTEM	**14. MEMORY REQUIREMENTS**	**15. UTILITY PROGRAMS**
KRONOS 2.1	RUN: $35,100_8$ words FTN: $45,600_8$ words	None
16. TAPE DRIVES	**17. DISK/DRUM UNITS**	**18. SLOW CORE**
None	None	None
19. OTHER STORAGE	**20. TERMINALS**	**21. GRAPHICS**
None	None	None

22. OTHER OPERATIONAL REQUIREMENTS

None

23. COMMENTS

None

IMPLEMENTATION RECORD

01. NAME	02. GENUS	03. VERSION	04. LEVEL	05. GESA NUMBER
MAGSET	II	1	A	E02-0004-00016
07. HARDWARE: CDC 6400		08. LOCATION: University of Colorado Computing Center Boulder, Colorado 80309		23. IMPLEMENTATION DATE: 1 September 1976

24. CONTROL STATEMENTS

RUN Compiler

```
Job Card
Account Card
RUN.
MAP,P.  (optional)
LGO.
7/8/9

    PROGRAM MAGSET (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)

        (Source Deck)

7/8/9

        (Data Deck)

6/7/8/9
```

FTN Compiler

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Job Card
Account Card
FTN,EL=A,R=3
MAP,P.  (optional)
LGO.
7/8/9

    PROGRAM MAGSET (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)

        (Source Deck)

7/8/9

        (Data Deck)

6/7/8/9
```

IMPLEMENTATION RECORD

01. NAME	02. GENUS	03. VERSION	04. LEVEL	05. GESA NUMBER
MAGSET	II	1	A	EØ2-ØØØ4-ØØØ16

06. DESCRIPTION

MAGSET-II is a computer program to calculate the magnitude of settlement of a multi-layered soil profile containing cohesive and/or granular layers.

07. HARDWARE	08. LOCATION	09. IMPLEMENTATION DATE
CDC 6400	University of Colorado Computing Center Boulder, Colorado 80309	1 September 1976
10. CHARACTER CODE	**11. CONTROL LANGUAGE**	**12. COMPILER**
BCD	KCL	MNF
13. OPERATING SYSTEM	**14. MEMORY REQUIREMENTS**	**15. UTILITY PROGRAMS**
KRONOS 2.1	$33{,}700_8$ words	None
16. TAPE DRIVES	**17. DISK/DRUM UNITS**	**18. SLOW CORE**
None	None	None
19. OTHER STORAGE	**20. TERMINALS**	**21. GRAPHICS**
None	None	None

22. OTHER OPERATIONAL REQUIREMENTS

None

23. COMMENTS

None

IMPLEMENTATION RECORD

01. NAME	02. GENUS	03. VERSION	04. LEVEL	05. CESA NUMBER
MAGSET	II	1	A	E02-0004-00016

07. HARDWARE	09. LOCATION	09. IMPLEMENTATION DATE
CDC 6400	University of Colorado Computing Center Boulder, Colorado 80309	1 September 1976

24. CONTROL STATEMENTS

```
Job Card
Account Card
MAP,P.  (optional)
MNF,B.
LGO.
7/8/9

    PROGRAM MAGSET (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)

        (Source Deck)

7/8/9

        (Data Deck)

6/7/8/9
```

IMPLEMENTATION RECORD

01. NAME	02. GENUS	03. VERSION	04. LEVEL	05. GESA NUMBER
MAGSET	II	1	A	E02-0004-00016

06. DESCRIPTION

MAGSET-II is a computer program to calculate the magnitude of settlement of a multi-layered soil profile containing cohesive and/or granular layers.

07. HARDWARE	08. LOCATION	09. IMPLEMENTATION DATE
IBM 370/145	CADPAC University of Colorado Boulder, Colorado 80309	1 September 1976
10. CHARACTER CODE	**11. CONTROL LANGUAGE**	**12. COMPILER**
BCD	JCL	FORTRAN IV G Level 21
13. OPERATING SYSTEM	**14. MEMORY REQUIREMENTS**	**15. UTILITY PROGRAMS**
OS/VS1 Release 3	Approx. 132,000 bytes	None
16. TAPE DRIVES	**17. DISK/DRUM UNITS**	**18. SLOW CORE**
None	None	None
19. OTHER STORAGE	**20. TERMINALS**	**21. GRAPHICS**
None	None	None

22. OTHER OPERATIONAL REQUIREMENTS

None

23. COMMENTS

None

IMPLEMENTATION RECORD

01. NAME	02. GENUS	03. VERSION	04. LEVEL	05. GESA NUMBER
MAGSET	II	1	A	EØ2-ØØØ4-ØØØ16

07. HARDWARE	08. LOCATION	09. IMPLEMENTATION DATE
IBM 370/145	CADPC University of Colorado Boulder, Colorado 80309	1 September 1976

24. CONTROL STATEMENTS

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//MAGSET JOB (13800,VP,P,'MAGSET'),CLASS=G,TIME=10,MSGLEVEL=(1,1)

//STEP1 EXEC FORTGCLG,PARM,FORT='MAP,BCD'

//FORT SYSIN DD *

     (Source Deck)

//GO SYSIN DD *

     (Data Deck)
```

Chapter 1 - ENGINEERING DOCUMENTATION

1.1 Introduction

MAGSET (MAGnitude of SETtlement) is a computer program for calculating the magnitude of settlement of a multi-layered soil profile containing granular and/or cohesive soil layers.

Settlement calculations in cohesive layers are based on Terzaghi's one-dimensional consolidation theory. The initial geostatic effective stress is calculated by the program for each layer. Input options are provided so that initial states of effective stress caused by external loadings may be added to or replace the initial insitu effective stress. An individual history of effective stress increments can be input for each layer in the soil profile or one effective stress history can be input for the entire soil profile. When a single effective stress history effects the entire soil profile, any stress distribution with depth can be specified. The deformation characteristics of cohesive soils are input as curves of void ratio or strain plotted against effective stress.

Settlement calculations in granular soil layers are based on empirical correlations to static or dynamic penetration field tests. The methods of Meyerhof and D'Appolonia use data from the Standard Penetration Test blowcount. Schmertmann's method uses data from the static cone penetrometer.

Settlements are not calculated for any layer designated as incompressible. This facility may be particularly useful if it is desired to use an independent method to calculate sand settlements.

The soil profile geometry may be specified in terms of depths or elevations. The program accepts any set of consistent units.

1.2 Soil Profile

The multi-layered soil profile is defined by the user. The soil profile consists of (n) contiguous layers. The layers defining the soil profile may be either granular, cohesive, or incompressible. No calculations are performed in a layer that is specified incompressible.

The definition of the (n) soil layers may or may not coincide with the natural geotechnical stratification. The individual layers should be selected in such a way that the soil properties at one "average" point in the layer can be assumed to govern the settlement contribution of the layer. For example, a thick compressible stratum will usually be subdivided into several smaller layers for calculation purposes.

The soil profile geometry is specified in terms of depths or elevations. The program performs all internal calculations in terms of depths. The program will convert depths or elevations to a specified datum if a benchmark elevation and an elevation difference are provided.

1.3 Settlement in Cohesive Soils

The prediction of consolidation settlement in the cohesive soil layers requires a knowledge of the deformation relationships and the effective stress history. The deformation relationships are given by either void ratio-effective stress curves or strain-effective stress curves. These curves are usually developed from oedometer tests. The effective stress history is related to the manner in which the soil is loaded, i.e. the load history.

1.3.1 Load History

The load history contributing to the settlement follows the sequence of construction operations or natural phenomena which contribute to the consolidation settlement. Some of the construction operations which make up a load history are as follows:

1) Unloading of the soil due to excavation.

2) Temporary and/or permanent changes in ground water conditions.

3) Loading due to the construction of the structure. This is the addition of the structural dead load.

4) Loading and unloading due to variations in the live load during the useful life of the structure.

5) Effects of adjacent construction.

Each applied load (or unload) imposes an effective stress distribution on the soil. For example, an effective stress (σ') profile is shown in Figure 1. The natural (insitu) effective stress distribution is shown by curve (1). If the first step in the construction sequence is an excavation the effective stress distribution curve changes from (1) to (2). A building loading further changes the effective stress distribution from curve (2) to curve (3).

The consolidation settlement is governed by the effective stress history. This history, in turn, is governed by the load history. For the example shown in Figure 1, the insitu effective stress for the (*i*th) layer is at the point (a). The change in effective stress due to excavation changes the (*i*th) layer effective stress to point (b), producing an increment of effective stress of ($-\Delta\sigma'_b$), where the minus (-) sign is for unloading. The subsequent foundation loading changes the (*i*th) layer effective stress to point (c), producing an increment of effective stress ($\Delta\sigma'_c$). It is these increments of effective stress which produce the settlement contribution of the (*i*th) layer.

1.3.2 Specifying the Effective Stress History

The effective stress history for the soil profile must be established for the calculation of settlements in the cohesive soil layers. This history is input to the program by specifying

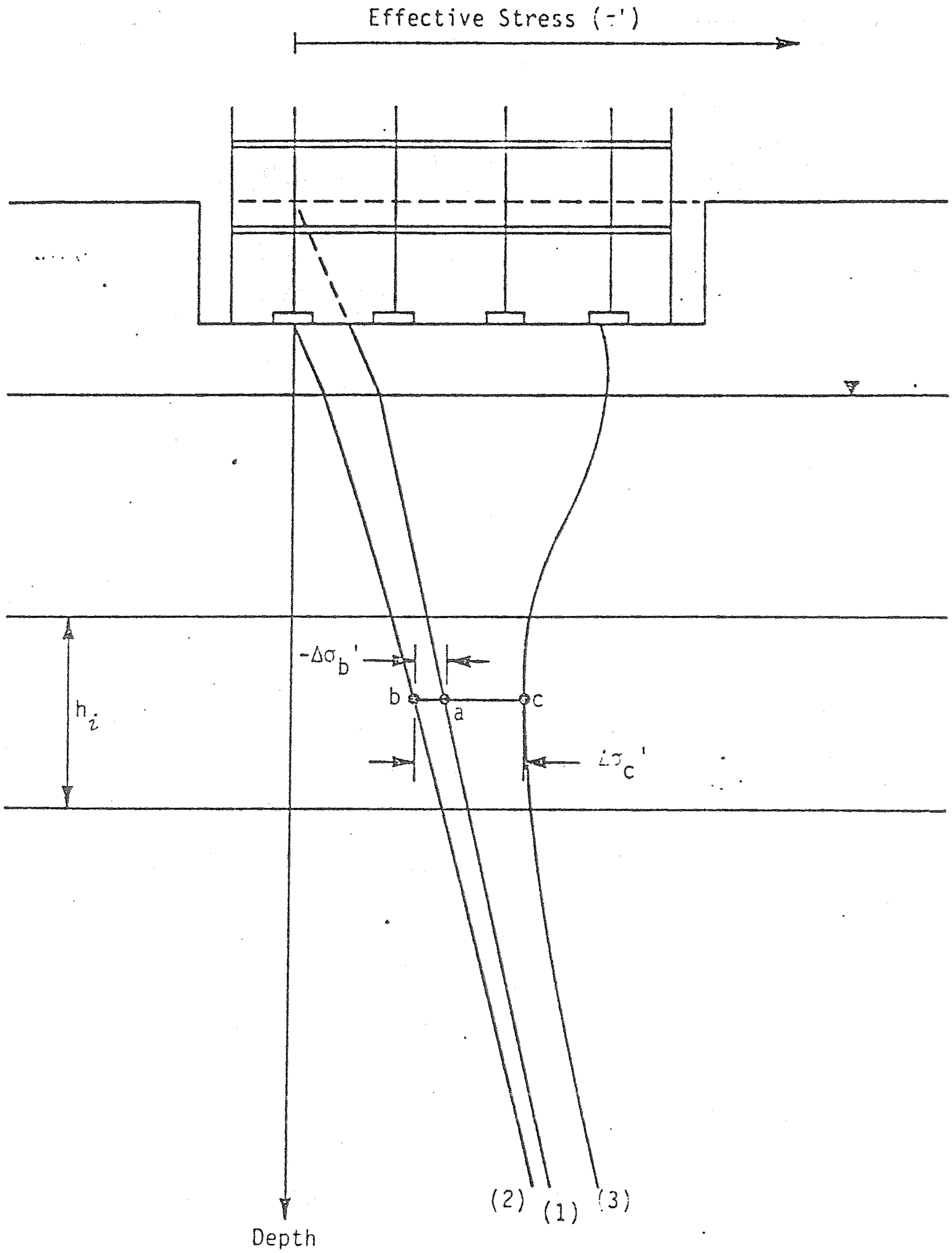

Figure 1
EFFECTIVE STRESS HISTORY

a series of effective stress increments in each cohesive soil layer.

The effective stress increments are specified in the following notation. The index (i) refers to a cohesive layer number where (i) can range in value from one (1) to (n). The index (j) refers to the effective stress history point. There are (m) increments of effective stress where (j=1, 2, ...m). Thus, ($\sigma'_{j,i}$) is the effective stress for the (ith) layer at the end of the (jth) effective stress increment ($\Delta\sigma'_{j,i}$).

A general relationship for the effective stress increment ($\Delta\sigma'_{j,i}$) is,

$$\Delta\sigma'_{j,i} = \sigma'_{j,i} - \sigma'_{j-1,i} \quad . \tag{1}$$

The insitu effective stress for the (ith) layer is ($\sigma'_{0,i}$). This value may be either specified or calculated by the program.

The effective stress increments should be specified to represent an "average" value in each cohesive layer that is assumed to govern the settlement contribution of the layer.

There are three ways in which the effective stress history can be input to the program. They are as follows:

1) The effective stress history is specified for each cohesive layer. The effective stress increments ($\Delta\sigma'_{j,i}$) are input by layer. There are (m) values of effective stress input for each cohesive layer.

2) The effective stress history is uniform with depth. One set of (m) effective stress increment values ($\Delta\sigma'_j$) is input which applies to all cohesive layers. The program calculates the effective stress increments ($\Delta\sigma_{j,i}$) for each cohesive layer as,

$$\Delta\sigma'_{j,i} = \Delta\sigma'_j \quad . \tag{2}$$

3) The effective stress history is specified with a layer dependent stress distribution function (f). One set of (m) effective stress increment values ($\Delta\sigma'_j$) is input. Also, the stress distribution function value (f_i) is input for each cohesive layer. The program calculates the effective stress increments ($\Delta\sigma'_{j,i}$) for each cohesive layer as,

$$\Delta\sigma'_{j,i} = \Delta\sigma'_j * f_i \quad . \tag{3}$$

1.3.3 Deformation Relationships

The program assumes that the deformation of the cohesive soil layers is governed by an effective stress-strain relationship. This relationship may be specified by a strain-effective stress curve or a void ratio-effective stress curve. These curves are simplified as a series of straight line segments on a semi-logarithmic plot.

The void ratio-effective stress relationship shown in Figure 2 pertains to the example previously given for the effective stress history provided in Figure 1.

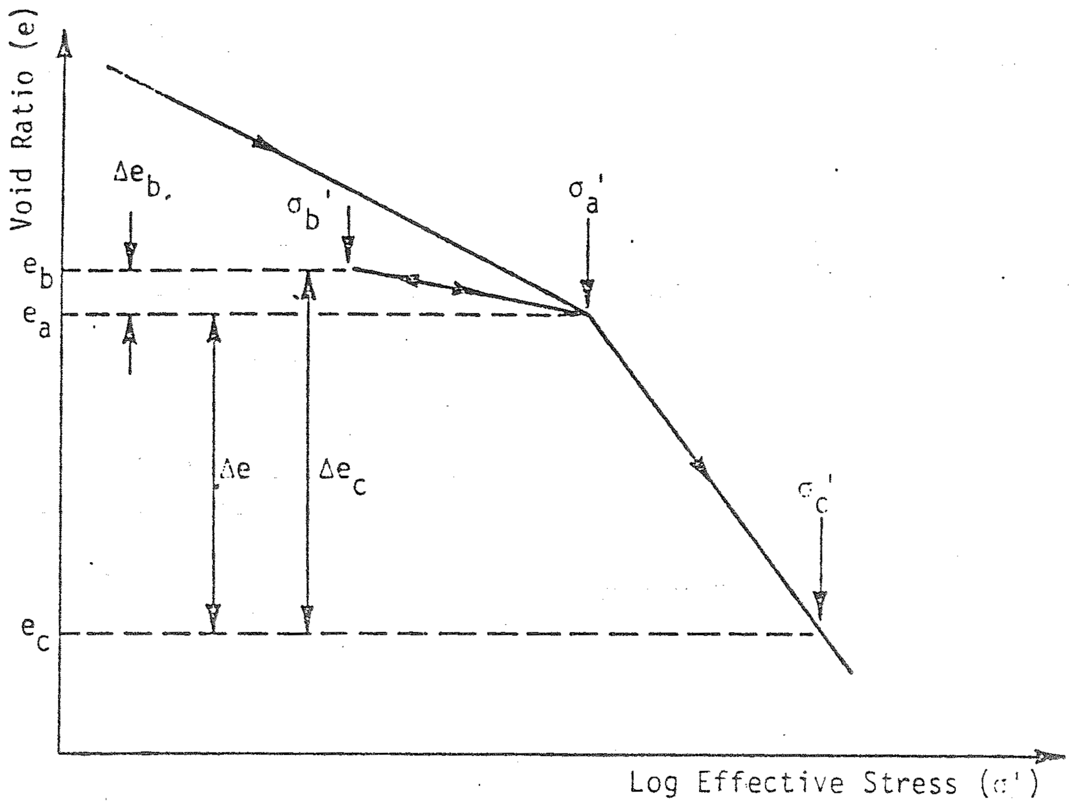

FIGURE 2

EXAMPLE VOID RATIO-EFFECTIVE STRESS RELATIONSHIP

In Figure 2, the states of effective stress represented by (σ_a') (σ_b'), and (σ_c') are the states of stress shown by points (a), (b), and (c) respectively in Figure 1.

The deformation, as characterized by the void ratio (e) has the following history.

1) Starting from (e_a, σ_a'), the soil expands to a point (e_b, σ_b'). The net change in void ratio due to excavation is (Δe_b).

2) Subsequent to excavation the foundation loading traces the curve from (e_b, σ_b') to (e_c, σ_c'), resulting in a net

compression of (Δe_c).

3) The net change in void ratio due to the construction sequence (Δe) is,

$$\Delta e = \Delta e_c - \Delta e_b \qquad (4)$$

Some characteristics of the void ratio-effective stress curve shown in Figure 2 which are characteristic of a more general relationship are as follows:

1) If a laboratory curve is developed by loading only, a unique curve called the "primary loading envelope" is formed.

2) The primary loading envelope can be formed by several straight line segments. Each line segment is called a "primary loading segment".

3) The unloading path has a slope which may be different than the primary loading segment from which it developed.

4) The slope of all the unloading paths developed from the same primary loading segment will be the same. The unloading slopes, however, will be different for different primary loading segments.

5) A reloading will follow the unloading path until the primary loading envelope is reached. This envelope will be followed thereafter.

The slope of the void ratio-effective stress curve is measured by the compression index (C_c) and the expansion index (C_e). Following the rules given above, the compression index applies to the primary loading envelope, while the expansion index applies to the unloading and reloading curves. In the reloading case, the applicability of (C_e) is only in the region where the effective stress is less than the effective stress for unloading. Beyond that point the compression index (C_c) applies.

Using Figure 2 as an example, the compression index (C_c) for ($\sigma' > \sigma'_a$) is,

$$e = e_a - C_c \log_{10}(\sigma'/\sigma'_a). \qquad (5)$$

The expansion index (C_e) for ($\sigma' < \sigma'_a$) is,

$$e = e_a - C_e \log_{10}(\sigma'/\sigma'_a). \qquad (6)$$

In any one of the paths of Figure 2, a strain increment can be defined. The strain increment developed from the initial unloading due to excavation ($\Delta\varepsilon_b$) is

$$\Delta\varepsilon_b = \Delta e_b/(1+e_a), \qquad (7)$$

The strain increment developed due to the final loading ($\Delta\varepsilon_c$) is,

$$\Delta\varepsilon_c = \Delta e_c/(1+e_b). \qquad (8)$$

In addition it is convenient to calculate the constrained compressibility (m_v). This is useful for input to programs which calculate the progress of settlement. Again referring to Figures 1 and 2, the constrained compressibility (m_{vb}) for unloading is,

$$m_{vb} = \Delta\varepsilon_b/\Delta\sigma'_b, \qquad (9)$$

and the constrained compressibility for loading is,

$$m_{vc} = \Delta\varepsilon_c/\Delta\sigma'_c. \qquad (10)$$

Generalizing the above, a notation can be established for a general void ratio-effective stress relationship consisting of an arbitrary number of primary loading segments, as shown in Figure 3.

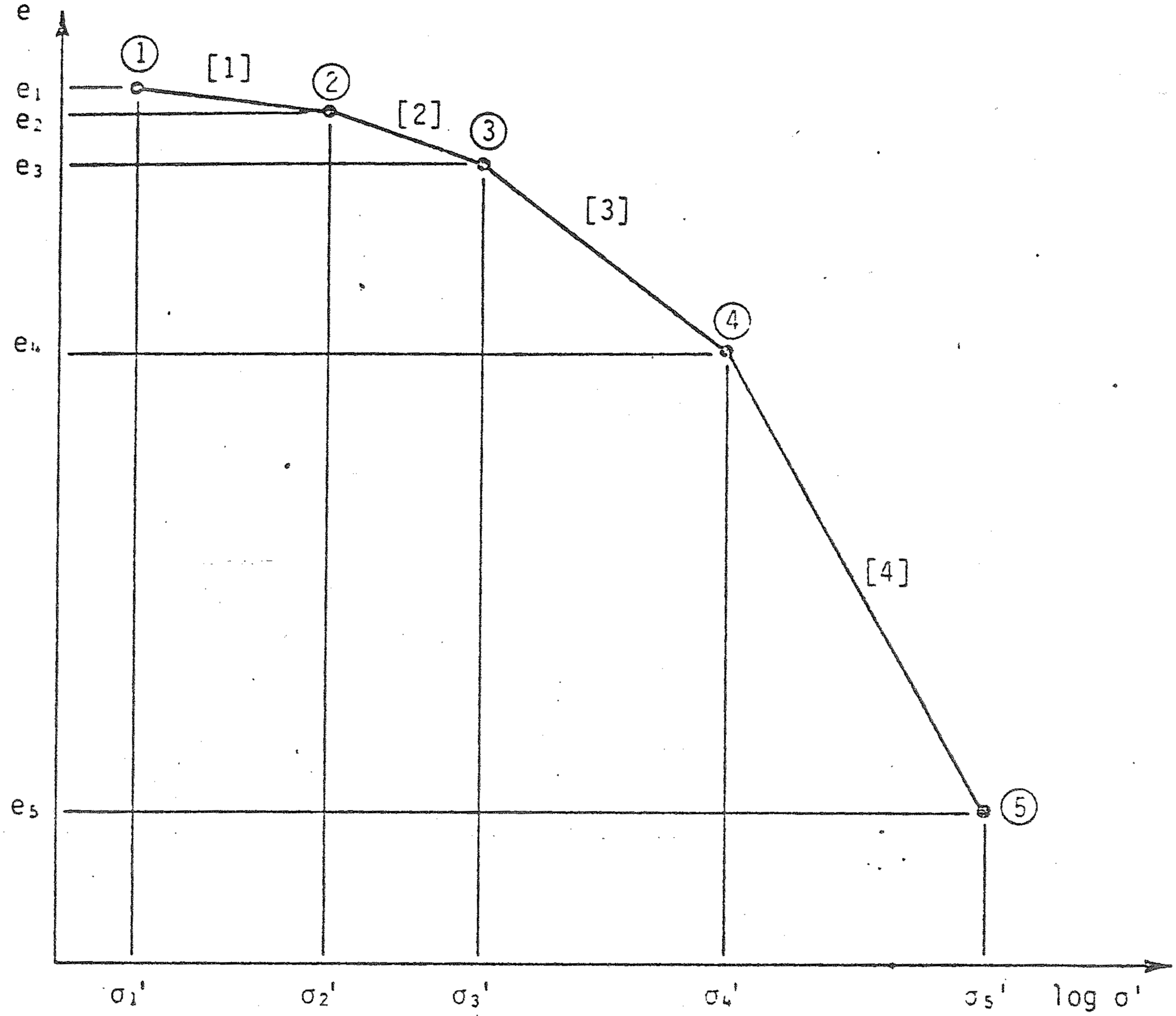

FIGURE 3

ARBITRARY VOID RATIO-EFFECTIVE STRESS RELATIONSHIP

Let the extremities of the primary line segments be indexed by (k) where there are (p) points defining the curve. Thus (k = 1, 2, 3, ...p). The primary loading segment between (k) and (k+1) is indexed (k). Thus as shown in Figure 3 there are 5 points and 4 lines.

From the viewpoint of notation, the effective stress ($\sigma'_{k,i}$) is the (kth) end of a primary loading segment for the void ratio-effective stress relationship for the (ith) layer. The void ratio ($e_{k,i}$) is similarly defined.

Figure 4 presents an arbitrary primary loading segment with an unload-reload line.

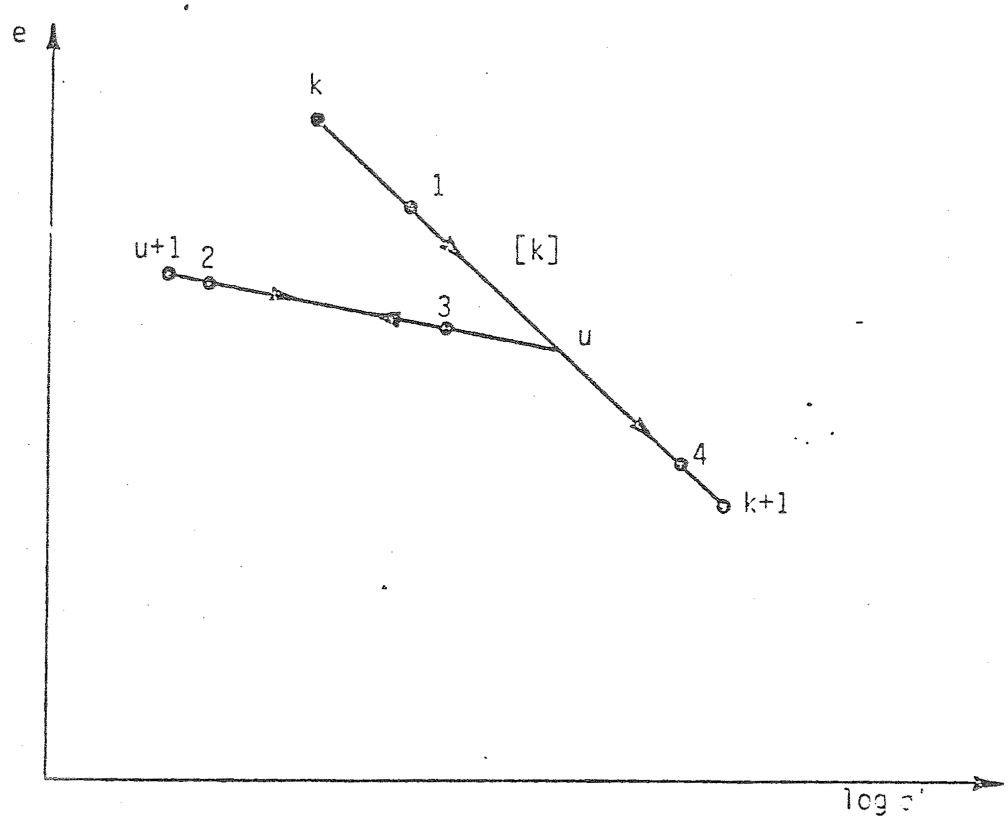

FIGURE 4

SEGMENT OF VOID RATIO-EFFECTIVE STRESS CURVE

This segment goes from point (k) to point (k+1). The unloading point is indexed (u). The compression index $(C_c)_{k,i}$ of the (kth) line of the (ith) layer is defined as,

$$e_i = e_{k,i} - (C_c)_{k,i} \log_{10}(\sigma_i'/\sigma_{k,i}') \qquad (11a)$$

where (e_i) is the resulting void ratio, and the arbitrary effective stress (σ_i') is,

$$\sigma_{k,i}' < \sigma_i' < \sigma_{k+1,i}' \qquad (11b)$$

The expansion index $(C_e)_{k,i}$ associated with the (kth) line of the (ith) layer is defined as,

$$e_i = e_{k,i} - (C_e)_{k,i} \log_{10}(\sigma_i'/\sigma_{u,i}'), \qquad (12a)$$

where,

$$\sigma_{u+1,i}' < \sigma_i' < \sigma_{u,i}'. \qquad (12b)$$

As an example of the use of equations (11) and (12) consider the following four examples shown on Figure 4.

1) Let the effective stress history advance from $\sigma_{1,i}' \rightarrow \sigma_{4,i}'$. Then,

$$\Delta e_{4,i} = e_{1,i} - e_{4,i} = (C_c)_{k,i} \log_{10}(\sigma_{4,i}'/\sigma_{1,i}'). \qquad (13)$$

2) Let the effective stress history be, $\sigma_{1,}' \rightarrow \sigma_{u,i}' \rightarrow \sigma_{2,i}'$. Then the void ratio increment (Δe_i) must be calculated in two parts. First,

$$\Delta e_{u,i} = e_{1,i} - e_{u,i} = (C_c)_{k,i} \log_{10}(\sigma_{u,i}'/\sigma_{1,}'). \qquad (14a)$$

Then,

$$\Delta e_{2,i} = e_{u,i} - e_{2,i} = (C_e)_{k,i} \log_{10}(\sigma'_{2,i}/\sigma'_{u,i}), \quad (14b)$$

And the void ratio increment for the effective stress history is,

$$\Delta e_i = \Delta e_{u,i} + \Delta e_{2,i}, \quad (14c)$$

where the addition above is algebraic.

3) For a reloading effective stress history $\sigma'_{2,i} \rightarrow \sigma'_{3,i}$,

$$\Delta e_{3,i} = e_{2,i} - e_{3,i} = (C_e)_{k,i} \log_{10}(\sigma'_{3,i}/\sigma'_{2,i}) \quad (15)$$

4) Let the effective stress history be, $\sigma'_{2,i} \rightarrow \sigma_{u,i} \rightarrow \sigma'_{4,i}$. The void ratio increment (Δe_i) is calculated in two parts. First,

$$\Delta e_{u,i} = e_{2,i} - e_{u,i} = (C_e)_{k,i} \log_{10}(\sigma'_{u,i}/\sigma'_{2,i}) \quad (16a)$$

Then,

$$\Delta e_{4,i} = e_{u,i} - e_{4,i} = (C_c)_{k,i} \log_{10}(\sigma'_{4,i}/\sigma'_{u,i}). \quad (16b)$$

The net void ratio increment (Δe_i) is,

$$\Delta e_i = \Delta e_{u,i} + \Delta e_{4,i}, \quad (16c)$$

where the addition is algebraic.

In the general notation developed above the strain increment for the (jth) load history increment, and the (ith) layer ($\varepsilon_{j,i}$) is,

$$\Delta\varepsilon_{j,i} = \Delta e_{j,i}/(1+e_{j-1,i}). \qquad (17)$$

In the example given above and shown on Figure 4, the strain increments for the four effective stress history cases are as follows:

1) For the history, $\sigma'_{1,i} \rightarrow \sigma'_{4,i}$ the strain increment is,

$$\Delta\varepsilon_{4,i} = \Delta e_{4,i}/(1+e_{1,i}). \qquad (18)$$

2) For the history $\sigma'_{1,i} \rightarrow \sigma'_{u,i} \rightarrow \sigma_{2,i}$ the strain increment is the sum of the strain increments along the loading and unloading branches. Thus,

$$\Delta\varepsilon_{u,i} = \Delta e_{u,i}/(1+e_{1,i}), \qquad (19a)$$

$$\Delta\varepsilon_{2,i} = \Delta e_{2,i}/(1+e_{u,i}), \qquad (19b)$$

and

$$\Delta\varepsilon_{i} = \varepsilon_{u,i} + \varepsilon_{2,i} \qquad (19c)$$

where ($\Delta\varepsilon_i$) is the net strain increment over the full load history.

3) For the history, $\sigma'_{2,i} \rightarrow \sigma'_{3,i}$, then,

$$\Delta\varepsilon_{3,i} = \Delta e_{3,i}/(1+e_{2,i}). \qquad (20)$$

4) For the history, $\sigma'_{2,i} \rightarrow \sigma'_{u,i} \rightarrow \sigma'_{4,i}$, the strain increment is again decomposed into two separate calculations,

$$\Delta\varepsilon_{u,i} = \Delta e_{u,i}/(1+e_{2,i}), \qquad (21a)$$

and,

$$\Delta\varepsilon_{4,i} = \Delta e_{4,i}/(1+e_{u,i}). \qquad (21b)$$

The net strain increment is,

$$\Delta\varepsilon_{i} = \varepsilon_{u,i} + \varepsilon_{4,i}.$$

It is noted that in cases (1) thru (4) above there could be two definitions of the strain. These involve the establishment of the initial base used in the strain calculation. MAGSET consistently breaks all calculations in accordance with the slope of the void ratio-effective stress lines. When a decomposition takes place, the initial value used in the strain calculations is adjusted to account for the change in slope. This is opposed to a calculation which uses an absolute initial void ratio.

Using the general notation the constrained compressibility $(m_v)_{j,i}$ for the (jth) load history increment and the (ith) layer is,

$$(m_v)_{j,i} = \Delta\varepsilon_{j,i}/\Delta\sigma'_{j,i} \qquad (22)$$

If the deformation relationships are given as strain-effective stress curves, the strain calculations are simplified. The characteristics of the strain-effective stress curves are the same as the characteristics stated earlier for the void ratio-effective stress curve.

The strain-effective stress relationship shown in Figure 5 pertains to the example previously given for the effective stress history provided in Figure 1. The relationship between the strain-effective stress in Figure 5 and the void ratio-effective stress curve in Figure 2 can be seen by comparing the two curves.

The states of effective stress (σ_a'), (σ_b'), and (σ_c') are the same on both curves. The strains (ε_a), (ε_b), and (ε_c) correspond to the void ratios (e_a), (e_b), and (e_c). The two curves have the same general shape when the strain is plotted decreasing in the upward direction.

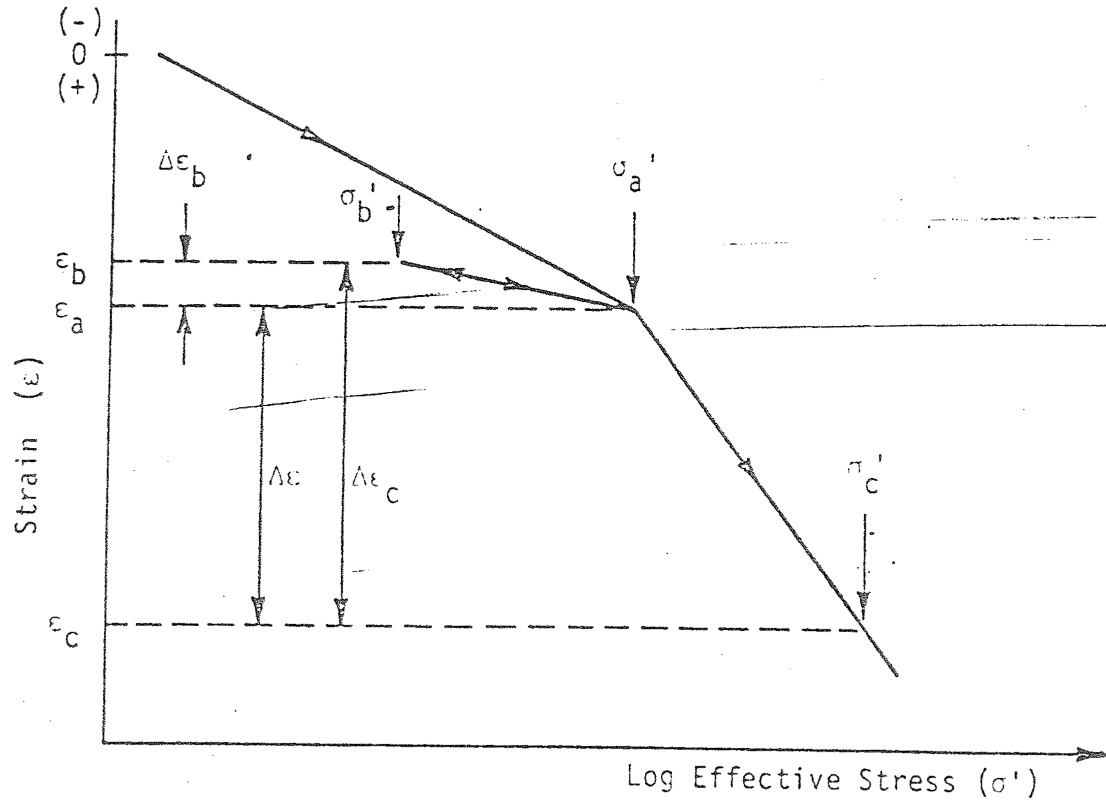

FIGURE 5

EXAMPLE STRAIN-EFFECTIVE STRESS RELATIONSHIP

The slope of the strain-effective stress curve is measured by the strain compression index ($C_{c\varepsilon}$) and the strain expansion index ($C_{e\varepsilon}$).

Using Figure 5 as an example, the strain compression index ($C_{c\varepsilon}$) for ($\sigma' > \sigma'_a$) is,

$$\varepsilon = \varepsilon_a + C_{c\varepsilon} \log_{10}(\sigma'/\sigma'_a) \quad (23)$$

The expansion index ($C_{e\varepsilon}$) for ($\sigma' < \sigma'_a$) is,

$$\varepsilon = \varepsilon_a + C_{e\varepsilon} \log_{10}(\sigma'/\sigma'_a) \quad (24)$$

The strain compression index ($C_{c\varepsilon}$) and the strain expansion index ($C_{e\varepsilon}$) are related to the compression index (C_c) and the expansion index (C_e) of the void ratio-effective stress curve. Referring again to Figure 2 and Figure 5, for the segment of the curve ($\sigma'_a < \sigma' < \sigma'_c$) these relationships are,

$$C_{c\varepsilon} = \frac{C_c}{1 + e_a}$$

and,

$$C_{e\varepsilon} = \frac{C_e}{1 + e_a}$$

Note that by definition the slopes (C_c), (C_e), ($C_{c\varepsilon}$), and ($C_{e\varepsilon}$) are all positive.

The strain increment calculations follow the same procedures used with the void ratio-effective stress curve. For example, the strain increment ($\Delta\varepsilon_b$) caused by the unloading due to excavation is,

$$\Delta\varepsilon_b = \varepsilon_b - \varepsilon_a$$

The strain increment developed due to the final loading ($\Delta\varepsilon_c$) is,

$$\Delta\varepsilon_c = \varepsilon_c - \varepsilon_a.$$

1.3.4 Specifying the Deformation Curves

The deformation relationships are input to the program in the form of void ratio-effective stress curves or strain-effective stress curves. There is one curve for each cohesive soil layer.

Two options are available for specifying the deformation curves. In each option a primary loading envelope of the deformation curve is defined by a sequence of points and lines as shown in Figure 6. The point of lowest effective stress is point (1) with the remainder of the points numbered sequentially in the order of increasing effective stress. The primary loading segments are also numbered sequentially with the line number equal to the lowest point number associated with the line.

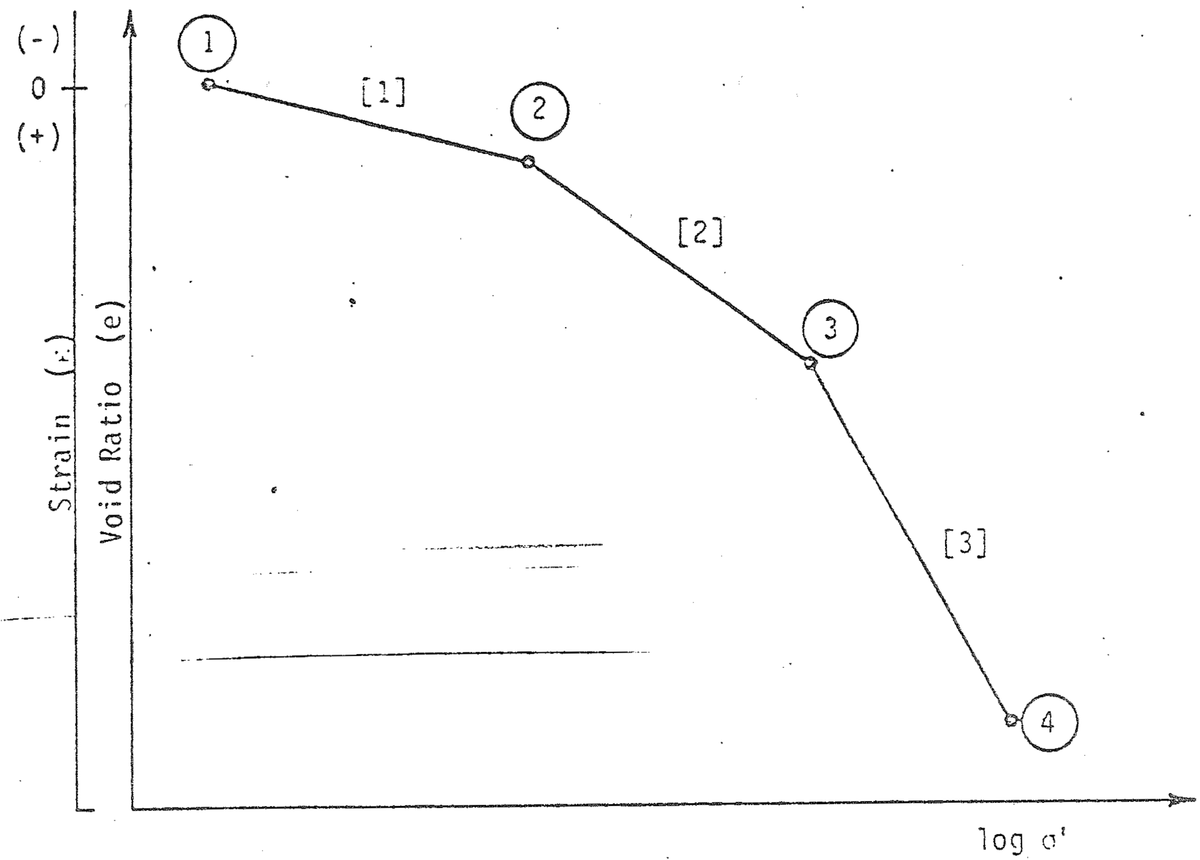

FIGURE 6

POINT AND LINE NUMBERS

The remaining information defining the deformation curve is specified at the points and lines of the primary loading envelope. This information is given by one of the following procedures.

Procedure 1:

a) The effective stress coordinates $(\sigma'_{k,i})$ at the point numbers of the primary loading envelope are given.

b) A reference coordinate $(e_{k,i}, \sigma'_{k,i})$ or $(\varepsilon_{k,i}, \sigma'_{k,i})$ at a point number on the primary loading envelope is specified.

c) The slopes (C_c, C_e) on ($C_{c\varepsilon}$, $C_{e\varepsilon}$) of each line on the curve are specified.

Procedure 2: a) Coordinates ($e_{k,i}$, $\sigma'_{k,i}$) or ($\varepsilon_{k,i}$, $\sigma_{k,i}$) are specified at each point number of the primary loading envelope.

b) Coordinates ($e_{u,i}$, $\sigma_{u,i}$) or ($\varepsilon_{u,i}$, $\sigma_{u,i}$) are specified at a point along the unloading path of each primary loading line.

c) The slopes (C_c, C_e) or ($C_{c\varepsilon}$, $C_{e\varepsilon}$) are calculated by the program.

1.4 Settlements in Granular Soils

Three methods are available in the program for estimating the settlement of granular layers. Two of the methods use data obtained from the Standard Penetration Test (SPT) and one uses data from the static cone penetrometer. The details of these methods will be presented in the sections to follow.

1.4.1 Meyerhof's Method

This method is based on an empirical correlation with the SPT blowcount. Meyerhof (1965) gave the following equations for the settlement of spread footings on sands and gravel,

$$S = C_D \frac{8q}{N} \left(\frac{B}{B + 1}\right)^2 \qquad \text{for } B > 4 \text{ ft} \qquad (28a)$$

or,

$$S = \frac{C_D 16q}{3N} \qquad \text{for } b \leq 4 \text{ ft} \qquad (28b)$$

where,

S = settlement magnitude - inches

C_D = foundation embedment correction factor

N = Standard Penetration Test blowcount

q = foundation pressure - $tons/ft^2$

B = footing width - feet

The foundation embedment correction factor (C_D) applied to Meyerhof's equation is,

$$C_D = 1 - \frac{D}{4B} \tag{29}$$

where,

D = difference in elevation between the ground surface surface and the foundation elevation.

The program controls the factor (C_D) so that it will not be less than 0.5.

1.4.2 D'Appolonia's Method

D'Appolonia's method (D'Appolonia, 1970) employs an empirical correlation, developed from field case studies, relating sand modulus to the SPT blowcount. Footing settlements are than estimated using elastic theory.

D'Appolonia's settlement equation is,

$$S = U_0 U_1 \frac{qB}{M} \tag{30}$$

where,

S = settlement magnitude

U_0 = foundation embedment correction factor

U_1 = stratum thickness correction factor

q = average applied foundation pressure

B = smallest footing dimension

M = modulus of compressibility, $M = E/(1-\nu^2)$, where E is the modulus elasticity and ν is Poisson's ratio

Values of M, U_0, and U_1 are obtained from the correlations presented in Figure 11. Because D'Appolonia's correlation between modulus and SPT blowcount was developed for footing foundations on sand, there are restrictions on its use. The correlation should not be applied to raft foundations or to silts and sandy silts.

1.4.3 Schmertmann's Method

Schmertmann's (1970) method for the calculation of settlement beneath foundations on coarse silts to medium sand uses the static cone-bearing capacity to estimate insitu compressibility. Strains and settlements are then calculated utilizing this information.

Essentially, the settlement calculations by this method are an integration of strains. It is formulated as,

$$S = \int_0^\infty \varepsilon_z d_z \approx \Delta P \int_0^{2B} \left(\frac{I_z}{E_\ell}\right) dz \approx C_1 \Delta P \sum_0^{2B} \left(\frac{I_z}{E_\ell}\right) dz \quad (31a)$$

where,

C_1 = foundation embedment correction factor

Δp = $p - p_0$, where (p) is the foundation pressure and (p_0) is the overburden pressure at the foundation level

B = footing width

E = modulus of elasticity of the (ℓth) sand layer

I_z = strain influence factor

The embedment correction factor is,

$$C_1 = 1 - 0.5 \left(\frac{p_0}{\Delta p}\right) \quad (31b)$$

However, in accord with elasticity, C_1 should equal or exceed 0.5.

The summation in equation (31a) includes only the sand layers within the depth of influence of the footing.

The modulus of elasticity of the sand layers (E_ℓ) remains to be defined. Schmertmann proposed a simple correlation for design in common granular soils,

$$E = 2q_c \tag{32}$$

where (q_c) is the static cone-bearing capacity.

Because the correlation with (E) is empirical and is based on (q_c) as obtained from the use of the Delft static cone equipment, it is desirable that the q_c profile input to the program be obtained with similar equipment.

It is possible, but with reduced accuracy, to use this settlement calculation procedure in conjunction with standard penetration test data. Schmertmann suggests the following approximate correlation, usually conservative, between N in blows/foot and q_c in kg/cm^2. The ratios shown in the following table are only valid for the units given above.

Soil Type	q_c/N
Silts, sandy silts, slightly cohesive silt-sand mixture	2.0
Clean, fine to medium sands and slightly silty sands	3.5
Coarse sand and sands with little gravel	5.0
Sandy gravels and gravel	6.0

These conversions are only recommended as a temporary expedient until cone data can be used directly.

1.4.4 Strain Influence Factor

From the theory of elasticity, model studies, and experimental and computer simulations results, it is clear that the vertical strain under shallow foundations over homogeneous, free draining soils proceeds from a low value immediately under a footing to a maximum at a significant depth below the footing and thereafter diminishes with depth. This is considerably different from what would be expected when assuming a vertical strain distribution similar to the distribution of increase in vertical stress. Such an assumption is likely to be incorrect.

The curves in Figure 7 show the distribution of vertical strain below the center of a loaded area over a homogeneous soil. The curves a, b, and c shown in Figure 7 are from theoretical results using Poisson's ratio (ν) of 0.4 and 0.5 and on the results of D'Appolonia (1968).

Considering the information available for the vertical strain distribution, Schmertmann (1970) proposed that for practical work, a simple piecewise linear distribution for vertical strain can be used. This approximate distribution is shown as curve f in Figure 7. Almes (1974) used the distribution shown in curve g to represent the strain distribution.

Note that the distributions in curves f and g represent a vertical strain influence factor (I_z) and not vertical strain itself. From the theory of elasticity, the strain influence factor (I_z) is related to vertical strain (ε_z) by the relationship,

$$\varepsilon_z = \frac{p\, I_z}{E} \qquad (33)$$

where (p) is the footing pressure and (E) the modulus of elasticity.

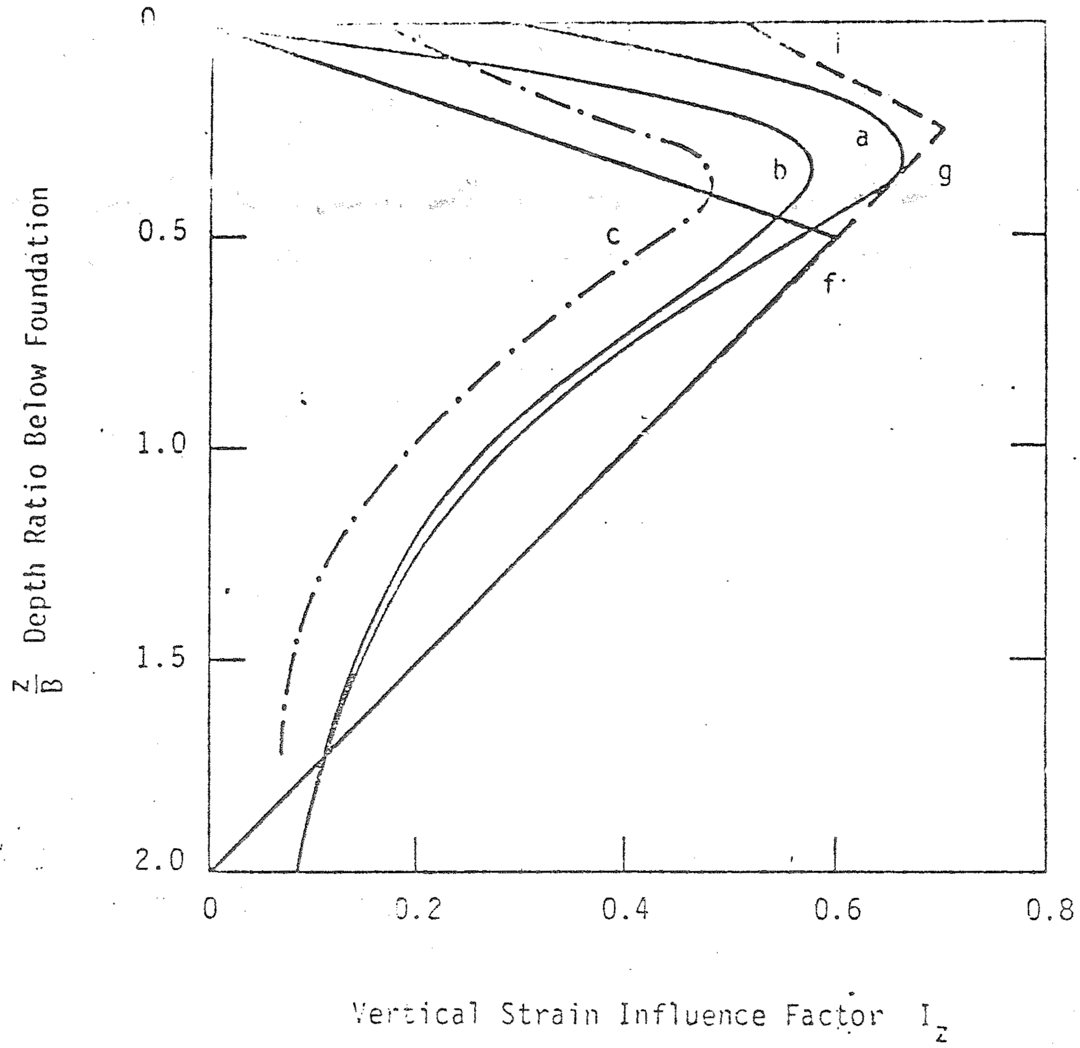

FIGURE 7

VERTICAL STRAIN INFLUENCE FUNCTION

The settlement calculations involving a layered system require some assumptions regarding the distribution of vertical strain under a footing. The following section describes the methods used by the program to compute settlements when the soil profile consists of a layered system within the depth of influence of the footing.

1.4.5 Layered Systems

Meyerhof's method assumes homogeneous material and D'Appolonia's method is strictly applicable only for homogeneous, isotropic, and elastic materials. However, both methods can give reasonably accurate results for non-homogeneous materials, i.e. layers of different blowcounts, provided that a representative average blowcount can be selected. This average blowcount is obtained using the vertical strain influence factor (I_z) to weight the blowcount in each sand layer over the depth of influence of the footing. The average weighted blowcount ($\overline{N}$) is calculated by,

$$\overline{N} = \frac{\sum_{0}^{2B} N_\ell \int_\ell \left(\frac{I_z}{E_\ell}\right) dz}{\int_0^{2B} I_z dz} \qquad (34)$$

where (N_ℓ) is the SPT blowcount in the (ℓth) sand layer.

The integrations and summation contained in equation 34 is calculated by MAGSET only for granular layers within the footing depth of influence. Non-granular layers are excluded. Thus the average weighted blowcount ($\overline{N}$) obtained from equation (30) is an average for the sand layers only. When this value is used in the Meyerhof and D'Appolonia relationships the result is the settlement that would occur in a homogeneous sand with a blowcount of ($\overline{N}$). If non-granular layers are present within the depth of influence, this settlement must be reduced by the ratio between the strain within the sand layers and the total strain within the depth of influence to obtain the settlement in the sand layers only.

The distribution of the strain influence factor and the depth of influence can be completely specified. The depth of influence can be extended beyond a depth of twice the footing width or it can be truncated if a rigid boundary layer is present. In the case of a rigid boundary layer no vertical strains occur beyond the boundary.

1.5 Units

Any consistant set of units may be used. All input data must be specified in terms of these units. However, Meyerhof's equation is an empirical relationship that is units dependent. Therefore if Meyerhof's method is used two conversion factors must be input which will convert the users units into the units necessary for Meyerhof's equation.

1.6 References

Almes, R. G., (1974), "SETTLE, Foundation Settlement Analysis", Users Manual for BASIC Language Version for IBM System 3, Model 6, E. D'Appolonia Consulting Engineers.

D'Appolonia, D. J., D'Appolonia, E. and Brissette, R. F., (1968), "Settlement of Spread Footings on Sand", Journal of the Soil Mechanics and Foundation Division, ASCE, 94, No. SM3, pp. 735-760.

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Lambe, T. W., and Whitman, R. V., (1969), Soil Mechanics, John Wiley and Sons, Inc., New York.

Meyerhof, G. G., (1965), "Shallow Foundations", Journal of the Soil Mechanics and Foundation Division, ASCE, 91, No. SM2, pp. 21-31.

Partyka, V., (1976), "MAGSET, Magnitude of Settlement, Reference Documentation," University of Colorado Computing Center, GESA Report No. 76-10.

Sanglerat, G., (1970), The Penetrometer and Soil Exploration, Elsevier Publishing Company, Amsterdam.

Schiffman, R. L. and Helgason, J. A., (1972), "MAGSET-I, Version 1.0, A Computer Program to Calculate Magnitude of Settlement", Computing Center, University of Colorado, Report No. 72-24.

Schmertmann, J., (1970), "Static Cone to Compute Static Settlement over Sand", Journal of the Soil Mechanics and Foundation Division, ASCE, 96, No. SM3, pp. 1011-1043.

Taylor, D. W., (1948), Fundamentals of Soil Mechanics, John Wiley and Sons, Inc., New York.

Terzaghi, K. and Peck, R. B., (1967), Soil Mechanics in Engineering Practice, John Wiley and Sons, Inc., New York.

(A) Data is input to MAGSET in the order presented below.

2.1 Problem Control Card

The problem control card reads the problem number, the number of layers, and the multiple problem indicator.

The READ variables are,

NPROB, NLAYER, LAST

The FORMAT is,

3I5 Free Field

The variables are defined in Table 2.1.

TABLE 2.1

PROBLEM CONTROL CARD

Variable	CC	Description
NPROB	1-5	Problem number.
NLAYER	6-10	Number of layers in the soil profile. Maximum value is 15.
LAST	11-15	Multiple problem indicator. = 0 ~~(or blank)~~ if current problem is not the last one in the data set. ≠ 0 if current problem is the last one in a data set.

Note: All entries are right justified integers.

2.2 Title Card

Title or description of the problem. May be up to 80 alphanumeric characters which will be echo printed to output.

The READ variable is,

ITITL~~(I), I = 1,28~~

The FORMAT is,

~~80A1~~ A66

The variable is defined in Table 2.2.

TABLE 2.2

TITLE CARD

Variable	CC	Description
ITITL	1-~~80~~ 66	Alphanumeric title or description of the problem. May be up to ~~80~~ 66 characters in length.

2.3 Problem Option Card

This card sets the options for the current problem.

The READ variables are,

IOPT(I), I = 1,8

The FORMAT is,

815 Free Field

The variables are defined in Table 2.3.

TABLE 2.3

OPTION CARD

Variable	CC	Description
IOPT(1)	1-5	Units indicator = 1 units to be printed in output will be specified = 2 no units will be printed in output
IOPT(2)	6-10	Insitu effective stress indicator = 1 the insitu effective stresses are calculated at the layer midpoints by the program using the unit weights of the soil layers and the unit weight of water. = 2 the insitu effective stress is input at each layer. = 3 the insitu effective stress is input at each layer and added to the insitu effective stress calculated by the program.
IOPT(3)	11-15	Effective stress history specification = 0 if there are no clay layers

Variable	CC	Description
		= 1 an effective stress history is input for each clay layer. = 2 one effective stress history is input that is valid for all clay layers in the soil profile. = 3 one effective stress history is input that is valid for all clay layers in the soil profile. A stress distribution function will be input for each layer. The effective stress history for each layer is determined by multiplying the layer's distribution function by the stress history of the profile.
IOPT(4)	16-20	Deformation curve type = 0 if there are no clay layers in the soil stratum. = 1 strain-effective stress curves = 2 void ratio-effective stress curves.
IOPT(5)	21-25	Deformation curve specification = 0 if there are no clay layers in the soil stratum. = 1 deformation curves are input using coordinate points of void ratio or strain versus effective stress. Slopes between coordinate points are calculated

Variable	CC	Description
		by the program.
		= 2 deformation curves are input using slopes, effective stress values and a reference coordinate.
IOPT(6)	26-30	Sand settlement method indicator
		= 0 if there are no sand layers in the soil stratum.
		= 1 Meyerhof's method.
		= 2 D'Appolonia's method.
		= 3 Schmertmann's method.
		= 4 all three of the above methods will be used to calculate sand layer settlements.
IOPT(7)	31-35	Vertical strain influence function
		= 0 if there are no sand layers in the soil stratum.
		= 1 curve g in Figure 7 will be used in the calculation of an average blowcount and/or the strain calculations.
		= 2 curve f in Figure 7 will be used in the calculation of an average blowcount and/or the strain calculations.
		= 3 a vertical strain influence function will be input.

Variable	CC	Description
IOPT(8)	~~36-40~~	Datum conversion option = 1 depths or elevations input will not be converted to a specified datum. = 2 depths or elevations input will be converted to a specified datum.
Note: All entries are right justified integers.		

2.4 Units Card

This card specifies the length and force units of the input data. It is input only if IOPT(1) = 1.

The READ variable is,

IUNIT(I), I = 1,8 2

The FORMAT is,

~~32A1~~ 2A16

The units designation is controlled in accordance with the column control given in Table 2.4.

TABLE 2.4

UNITS CARD

Variable	CC	Description
IUNIT	1-16	Length units. The entry should be centered within the specified field for presentability of output.
IUNIT	17-32	Force units. The entry should be centered within the specified field for presentability of output.

MAGSET-II does not distinguish units in the calculations. The input units are only printed in the output to indicate which set of consistent units were used for the input data.

2.5 Ground Water Data

This card inputs the unit weight of water and the ground water position.

The READ variables are,

GW, GWELEV

The FORMAT is,

2F10.0 Free field

The variables are defined in Table 2.5.

TABLE 2.5

GROUND WATER DATA

Variable	CC	Description
GW	1-10	Unit weight of water.
GWELEV	11-20	Depth or elevation of the ground water surface.

2.6 Layer Interface Cards

This sequence of cards defines the position of the layer interfaces. There are NLAYER + 1 of these cards.

The READ variables are,

L, DEPTH(L)

Read in a DO loop with a range from 1 to NLAYER + 1.

The FORMAT is,

I5, 5X, F10.0 Free Field

The variables are defined in Table 2.6.

TABLE 2.6

LAYER INTERFACE CARDS

Variable	CC	Description
L	1-5	Layer interface number. Right justified integer.
DEPTH(L)	11-20	Depth or elevation to the top of the (Lth) layer. If L = NLAYER + 1, the depth or elevation to the bottom of the last layer in the soil stratum

Interface positions must be input in numerical order or an error message will be printed and execution terminated.

2.7 Soil Properties Cards

This sequence of cards inputs the type and unit weights of the soil in each layer of the soil profile. There is one card per layer.

The READ variables are,

L, NTYPE(L), WGT(L)

Read in a DO loop with a range from 1 to NLAYER.

The FORMAT is,

(2I5, F10.0) Free Field

The variables are defined in Table 2.7.

TABLE 2.7

SOIL PROPERTIES CARD

Variable	CC	Description
L	1-5	Layer number. Right justified integer.
NTYPE(L)	6-10	Soil type for the (Lth) layer. Right justified integer. = 1 clay = 2 sand = 3 incompressible
WGT(L)	11-20	Total unit weight of soil in the (Lth) layer.

Soil property cards must be input in numerical order from 1 through NLAYER or an error message will be printed and execution will be terminated.

2.8 Datum Conversion Card

This card inputs the information needed to convert the input depths or elevations to elevations of a specified datum. It is input only if IOPT(8) = 2.

The READ variables are,

DATUM, DIFELV

The FORMAT is,

2F10.0 → Free Field

The variables are defined in Table 2.8.

TABLE 2.8

DATUM CONVERSION CARD

Variable	CC	Description
DATUM	1-10	Datum elevation.
DIFELV	11-20	Difference in elevation between the datum elevation and the top of the first layer in the soil stratum. This value is negative if the datum elevation is above the top of the first layer and positive if it is below the top of the first layer.

2.9 Insitu Effective Stress Cards

This sequence of cards inputs the insitu effective stress at the midpoint or an "average" point in each layer. These cards are input only if IOPT(2) = 2 or 3.

The READ variables are,

L, SINS1(L)

Read in a DO loop with the range 1 through NLAYER.

The FORMAT is,

I5, 5X, ~~F10.0~~ Free Field

The variables are defined in Table 2.9.

TABLE 2.9

INSITU EFFECTIVE STRESS CARDS

Variable	CC	Description
L	1-5	Layer number. Right justified integer.
SINS1(L)	11-20	The input insitu effective stress at the midpoint or "average" point in the (Lth) layer.

Insitu stress card must be input in numerical order from 1 through NLAYER or an error message will be printed and execution terminated.

2.10 Effective Stress Increments - Individual Soil Layers

These cards input a history of effective stress increments for each clay layer in the soil stratum. These cards are input only if IOPT(3) = 1.

The READ variables are,

L, SIGMA(L,NS), LS

The FORMAT is,

I5, 5X, F10.0, I5 → Free Field

The variables are defined in Table 2.10.

TABLE 2.10

EFFECTIVE STRESS INCREMENT - INDIVIDUAL SOIL LAYERS

Variable	CC	Description
L	1-5	Layer number. This value must be the number of a clay layer in the soil stratum. Right justified integer.
SIGMA(L,NS)	11-20	The (NSth) effective stress increment in the (Lth) layer.
LS	21-25	Last increment indicator. = 0 ~~(or blank)~~ if there are more effective stress increments to be input for the (Lth) layer. ≠ 0 if this effective stress increment is the last one in the (Lth) layer.

The effective stress increments for a clay layer are input sequentially while the clay layer number remains constant. Then the effective stress increments for the next clay layer are input. The clay layers must be input sequentially.

The maximum number of effective stress increments for a given clay layer is ten (10). All the clay layers in the soil stratum must have the same number of increments or an error message will be printed and execution will be terminated. In some cases it may be necessary to divide a natural effective stress increment into one or more segments so that every soil layer will have an equal number of increments.

2.11 Effective Stress Increments - Complete Soil Profile

These cards input a history of effective stress increments which apply to all the clay layers in the soil profile. The effective stress history may apply uniformly across all the layers in the profile. The effective stress history can also be proportioned by inputting a layer dependent stress distribution function to establish a different effective stress history for each layer. These cards are input only if IOPT(3) = 2 or 3.

The READ variables are,

SIG1(NS), LS

The FORMAT is,

F10.0, I5 Free field

The variables are defined in Table 2.11.

TABLE 2.11

EFFECTIVE STRESS INCREMENTS - COMPLETE SOIL PROFILE

Variable	CC	Description
SIG1(NS)	~~1-10~~	The (NSth) effective stress increment.
LS	~~11-15~~	Last increment indicator. = 0 ~~(or blank)~~ if there are more effective stress increments to be input. ≠ 0 if the effective stress increment is the last to be input.

The effective stress increments are input sequentially. The maximum number of effective stress increments is ten (10). An error message will be printed if either of the above conditions are violated and execution will be terminated.

2.12 Stress Distribution Function Cards

These cards input the value of the stress distribution function (f_i) in each clay layer of the soil stratum. These cards are input only if IOPT(3) = 3.

The READ variables are,

L, F(L)

The FORMAT is,

I5, 5X, F10.0 Free Field

The READ variables are defined in Table 2.12.

TABLE 2.12

STRESS DISTRIBUTION FUNCTION CARDS

Variable	CC	Description
L	1-5	Clay layer number. Right justified integer.
F(L)	11-20	Value of the stress distribution Function in the (Lth) layer.

There is one card for each clay layer. The clay layers must be input sequentially or an error message will be printed and execution will be terminated.

2.13 Deformation Curve - Coordinate Point Cards

These cards define the cohesive soil deformation curves by inputting a series of coordinate points in terms of void ratio or strain versus effective stress. These cards are input only if IOPT(5) = 1.

One curve is input for each clay layer in the soil profile. Figure 8 shows a typical deformation curve for a clay layer which is defined in terms of coordinate points. Deformation curves are input for each clay layer in the order which they occur in the soil profile. The following set of cards is input for each deformation curve:

2.13a Deformation Curve - First Coordinate Point Card

The READ variables for the first card defining the deformation curve is,

ILAYER, LINEPT(I,IPT), E(I,IPT), SIGMAP(I,IPT)

The FORMAT is,

2I5, 2F10.0 Free Field

The variables are defined in Table 2.13.

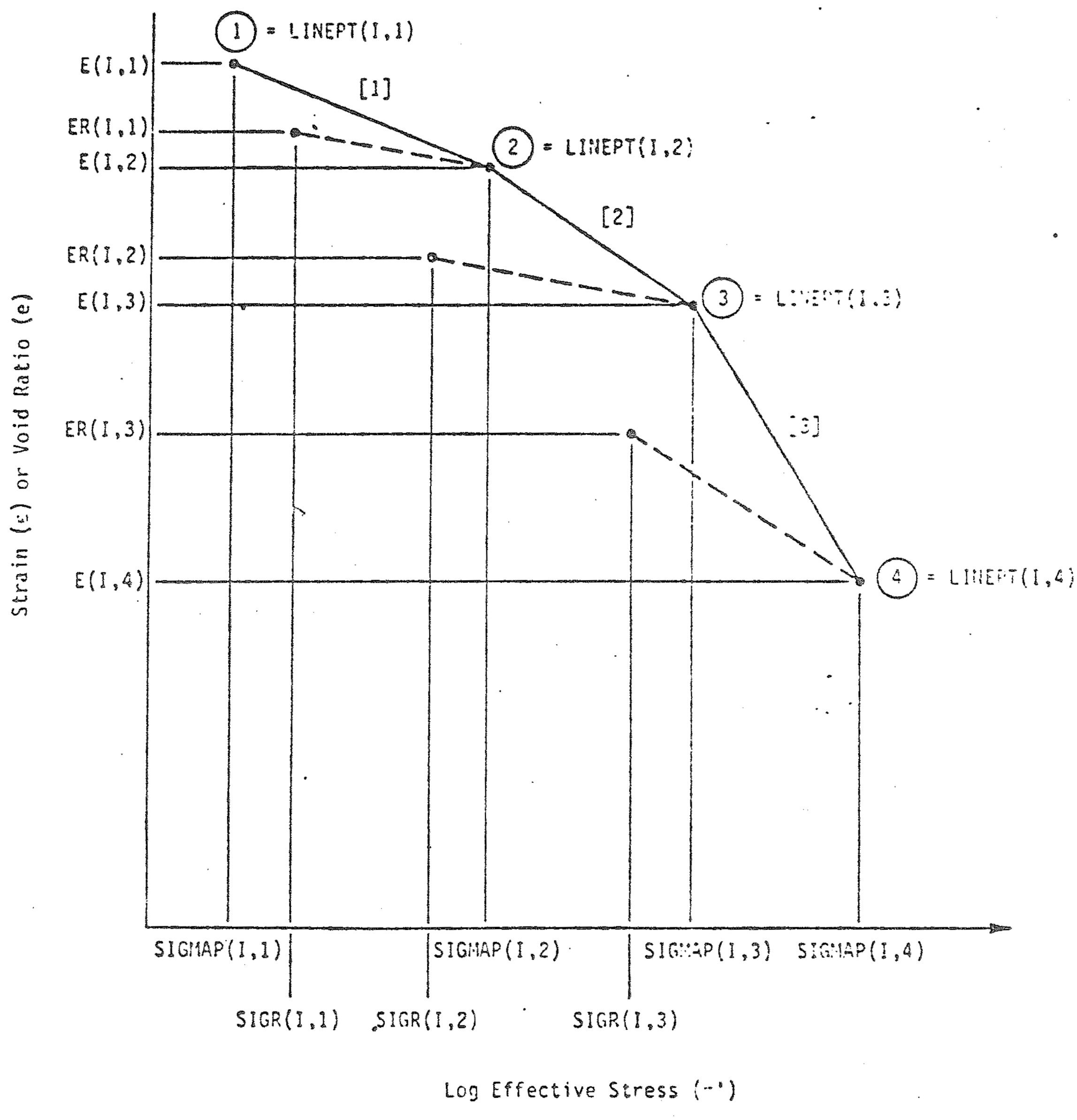


FIGURE 8

TYPICAL DEFORMATION CURVE FOR THE Ith LAYER

TABLE 2.13

FIRST COORDINATE POINT ON THE DEFORMATION CURVE

Variable	CC	Description
ILAYER	1-5	Clay layer number. Right justified integer.
LINEPT(I,IPT)	6-10	The first point on the deformation curve for the (Ith) layer. This value must be equal to 1. Right justified integer.
E(I,IPT)	11-20	The void ratio or strain coordinate at the first point on the deformation curve for the (Ith) layer.
SIGMAP(I,IPT)	21-30	The effective stress coordinate at the first point on the deformation curve for the (Ith) layer.

The first point must define the point of lowest effective stress on the deformation curve.

2.13b Deformation Curve - Subsequent Coordinate Point Cards

The subsequent points on the deformation curve for the (Ith) layer are now defined by the following cards.

The READ variables are,

ILAYER, LINEPT(I,IPT), E(I,IPT), SIGMAP(I,IPT),
ER(I,IPT-1), SIGR(I,IPT-1), LP

The FORMAT is,

(2I5, 4F10.0, I5) Free Field

The READ variables are defined in Table 2.14.

TABLE 2.14

COORDINATE POINTS ON THE DEFORMATION CURVE

Variable	CC	Description
ILAYER	1-5	Clay layer number. Right justified integer.
LINEPT(I,IPT)	6-10	Coordinate point on the deformation curve for the (Ith) layer. Right justified integer.
E(I,IPT)	11-20	The void ratio or strain at the coordinate point LINEPT(I,IPT).
SIGMAP(I,IPT)	21-30	The effective stress at the coordinate point LINEPT(I,IPT).
ER(I,IPT-1)	31-40	The void ratio or strain coordinate which will be used to calculate the expansion slope for the line segment (LINEPT(I,IPT) -1) on the deformation curve for the (Ith) layer.
SIGR(I,IPT-1)	41-50	The effective stress coordinate which will be used to calculate the expansion slope for the line segment (LINEPT(I,IPT)-1) on the deformation curve for the (Ith) layer.

Variable	CC	Description
LP	51-55	Last point indicator. A non-zero digit is input on the last point card of the deformation curve for the (Ith) layer. Right justified integer.

The points on the deformation curve must be input in order of increasing effective stress. The deformation curve sets must be in the order of the cohesive layers in the soil profile. If this order is not followed, an error message will be printed and execution terminated.

The compression and expansion slopes are calculated from the coordinates E, ER, SIGMAP, and SIGR. The coordinates E and SIGMAP define the primary loading envelope in addition to the slopes. The coordinates ER and SIGR are only used to define the expansion slope.

2.14 Deformation Curves - Slopes and Reference Cards

These cards define the deformation curves by the input of effective stress values, slopes, and a reference coordinate. They are input only if IOPT(5) = 2.

One deformation curve is input for each clay layer in the soil profile by three sets of cards. The sequence of cards is repeated for each deformation curve in the order of the clay layers in the soil profile. Figure 9 shows a typical deformation curve for a clay layer defined by effective stress values, slopes, and a reference stress. The data is input in the following manner.

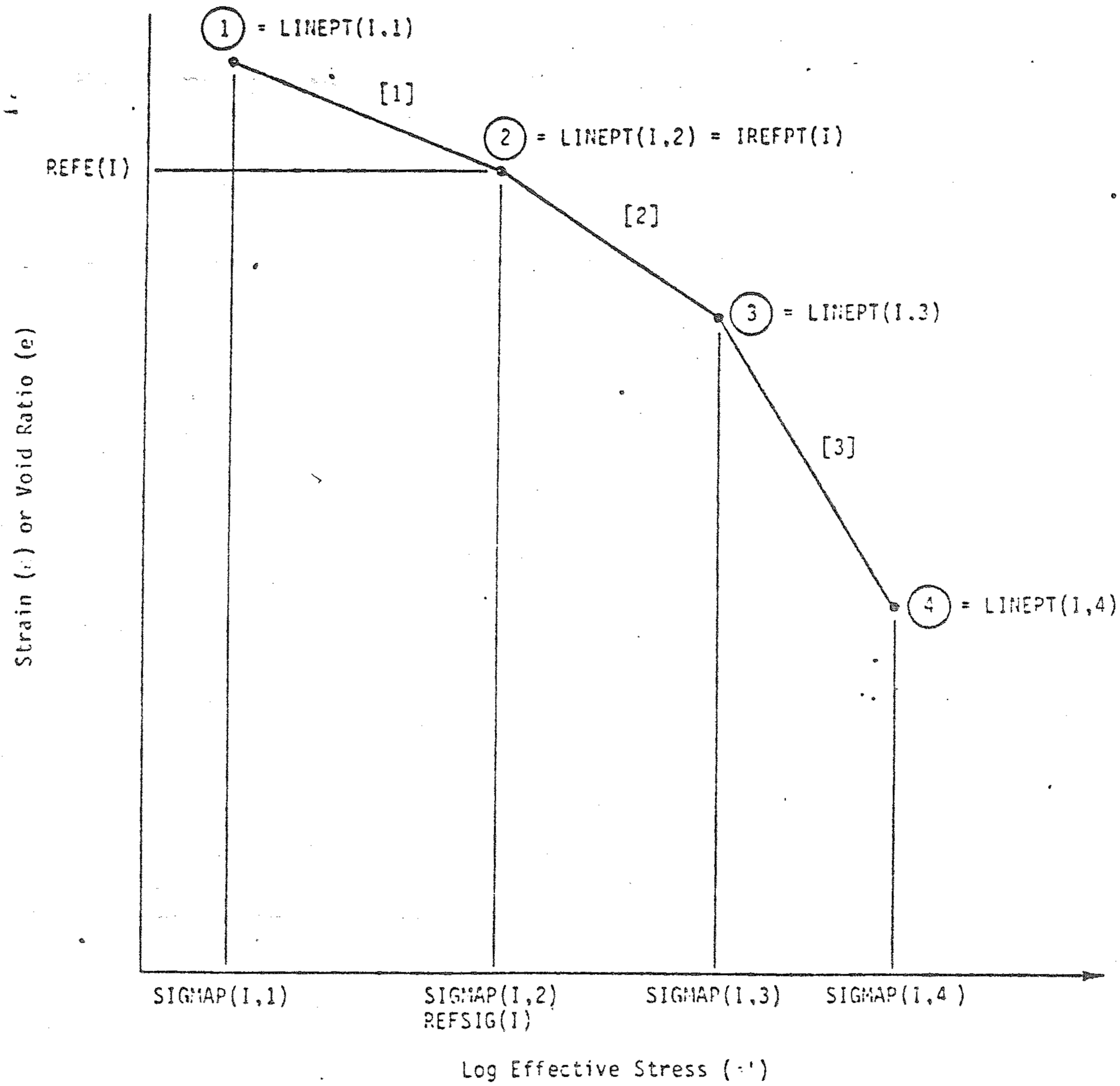


FIGURE 9

TYPICAL DEFORMATION CURVE FOR THE Ith LAYER

2.14a Effective Stress Cards

The first set of cards input the effective stress values on the deformation curve. The primary loading envelope of the curve is numbered sequentially in order of increasing effective stress. The point of lowest effective stress is point 1.

The READ variables of the effective stress data cards are,

ILAYER, LINEPT(I,IPT), SIGMAP(I,IPT), LP

The FORMAT is,

2I5, F10.0, I5 Free Field

The variables are defined in Table 2.15.

TABLE 2.15

EFFECTIVE STRESS CARDS

Variable	CC	Description
ILAYER	1-5	Clay layer number. Right justified integer.
LINEPT(I,IPT)	6-10	Point number on the deformation curve for the (Ith) layer. Right justified integer.
SIGMAP(I,IPT)	11-20	The effective stress value at point IPT on the deformation curve for the (Ith) layer.
LP	21-25	Last point indicator. A non-zero digit is input on the last point of the deformation curve for the (Ith) layer. Right justified integer.

If the effective stress points are not input in order of increasing effective stress an error message will be printed and execution terminated.

2.14b Reference Coordinate Card

This card inputs a reference coordinate on the deformation curve for the (Ith) layer. The reference coordinate must be at a point number on the deformation curve and the reference effective stress must be equal to the effective stress at that point.

The READ variables are,

ILAYER, IREFPT(I), REFE(I), REFSIG(I)

The FORMAT is,

~~2I5, 2F10.0~~ Free Field

The variables are defined in Table 2.16.

TABLE 2.16

REFERENCE COORDINATE CARD

Variable	CC	Description
ILAYER	1-5	Clay layer number. Right justified integer.
IREFPT(I)	6-10	Point on the deformation curve for the (Ith) layer that is to be used as the reference point.
REFE(I)	11-20	Void ratio or strain at the reference point for the (Ith) layer.
REFSIG(I)		Effective Stress at the reference point for the (Ith) layer

2.14c Compression and Expansion Slope Cards

The next set of cards inputs the compression and expansion slope of each line on the deformation curve. There is one card per line.

The READ variables are,

ILAYER, M, CC(I,M), CE(I,M)

The FORMAT is,

2I5, 2F10.0 Free Field

The READ variables are defined in Table 2.17.

TABLE 2.17

COMPRESSION AND EXPANSION SLOPE CARDS

Variable	CC	Description
ILAYER	1-5	Clay layer number. Right justified integer.
M	6-10	Line number on the deformation curve for the (Ith) layer.
CC(I,M)	11-20	Compression slope of the (Mth) line on the deformation curve for the (Ith) layer. If the curves are void ratio-effective stress curves, this value is the compression index C_c. If the curves are strain-effective stress curves, this value is the strain compression index $C_{c\varepsilon}$.

Variable	CC	Description
CE(I,M)	21-30	Expansion slope of the (Mth) line on the deformation curve for the (Ith) layer. If the curves are void ratio-effective stress curves this value is the expansion index C_e. If the curves are strain-effective stress curves this value is the strain expansion index $C_{e\varepsilon}$.

The line numbers must be in order beginning with 1 or an error message will be printed and execution terminated.

2.15 Penetration Resistance Cards

These cards input the penetration resistance of the sand layers in the soil stratum. They are input only if IOPT(6) ≠ 0. There is one card per sand layer.

The READ variables are,

L, BLOW(L), QC(L)

The FORMAT is,

I5, 5X, 2F10.0 Free Field

The READ variables are defined in Table 2.18.

TABLE 2.18

PENETRATION RESISTANCE CARDS

Variable	CC	Description
L	1-5	Sand layer number. Right justified integer.
BLOW(L)	11-20	The standard penetration test (SPT) blowcount (N) in blows per foot for the (Lth) layer. This ~~field is left blank~~ variable equal zero if IOPT(6) = 3.
QC(L)	21-30	The static cone penetration resistance (q_c) for the (Lth) layer. This field is left blank if IOPT(6) = 1 or 2.

These cards must be input in the order of the sand layers in the soil profile or an error message will be printed and execution will be terminated.

2.16 Footing Data Card

This card inputs the footing width, footing pressure, and the depth or elevation of the footing. This card is input only if IOPT(6) ≠ 0.

The READ variables are,

FP, FB, FDEPTH

The FORMAT is,

3F10.0 Free Field

The READ variables are defined in Table 2.19.

TABLE 2.19

FOOTING DATA CARDS

Variable	CC	Description
FP	1-10	The average footing pressure used to calculate settlement in the sand layers.
FB	11-20	The footing width to be used in the sand settlement calculations.
FDEPTH	21-30	The depth or elevation of the footing.

2.17 Strain Influence Function Cards

This card inputs the strain influence function (I_z) to be used for the sand settlement calculations. It is input only if IOPT(7) = 3. This function is defined by two lines as shown in Figure 10.

The strain influence lines are defined by the input of the I_z values coincident with z/B values at three distinct points on these lines. The first point defines a coordinate on line 1. The z/B value at this coordinate point represents the depth below the foundation at which the summation of the strain influence function, I_z, begins. The second point represents the coordinate at the intersection of lines 1 and 2. The z/B value at this coordinate point is also the depth below the foundation at which the strain influence function, I_z, is a maximum. The third point defines a coordinate on line 2. The z/B value at this coordinate is the depth below the foundation at which the summation of the strain influence function, I_z, ends. This depth is defined as the depth of influence at the foundation.

As an example, consider the vertical strain influence function shown in Figure 10. This strain influence function has a value of 0.2 immediately under the foundation and increases to a value of 0.7 at a depth of 0.375 B below the foundation and decreases to a value of 0.0 at the depth of influence 2.0 B.

The three sets of coordinates which define this strain influence function are defined in Table 2.20.

TABLE 2.20

EXAMPLE VERTICAL STRAIN INFLUENCE FUNCTION

Coordinate Point	z/B	I_z
1	0.0	0.2
2	0.375	0.7
3	2.0	0.0

The READ variables to define the vertical strain influence function are,

ZB(I), VIZ(I), I = 1,3

The FORMAT is,

6F10.0 Free Field

The READ variables are defined in Table 2.21.

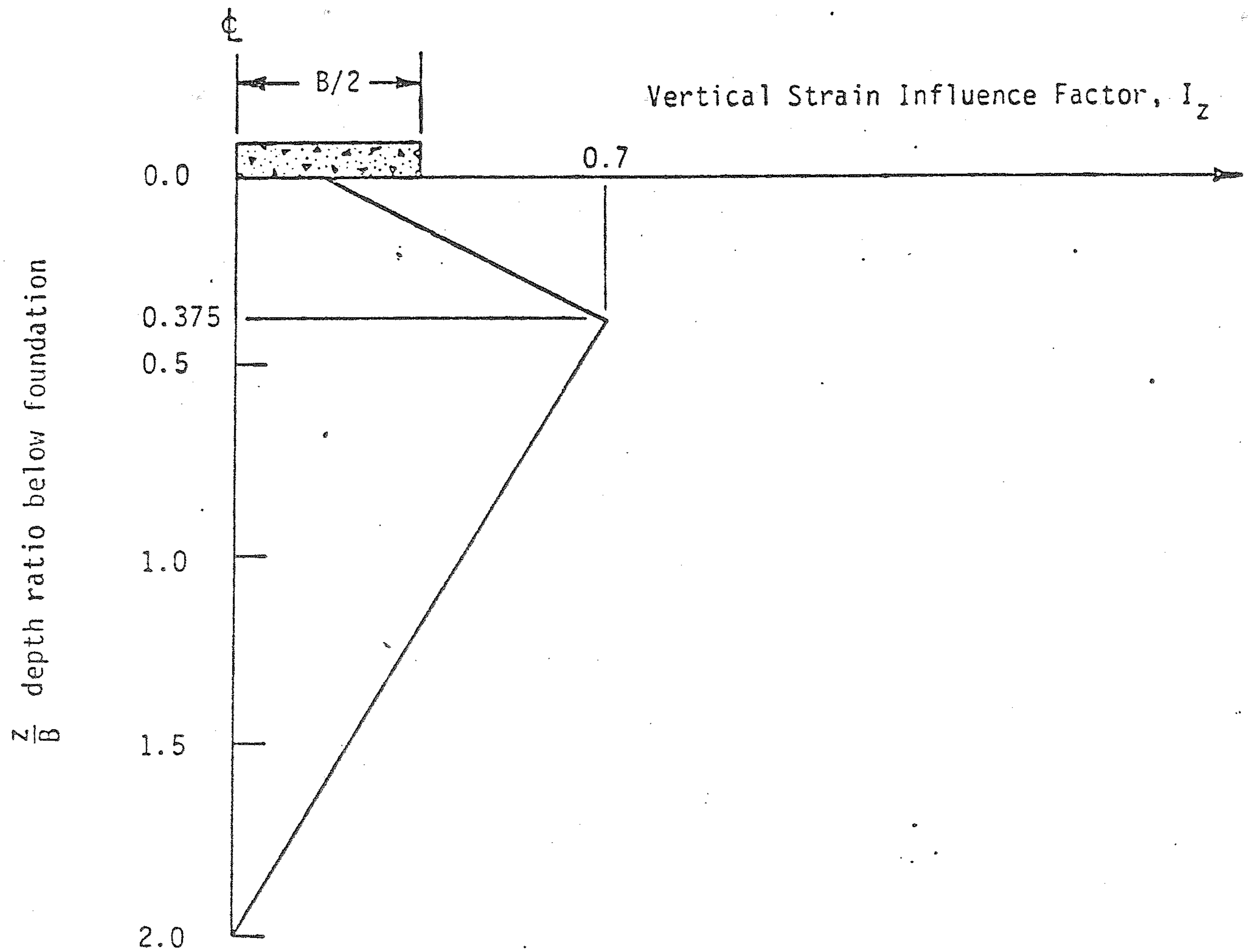


Figure 10
Example Vertical Strain Influence Function

TABLE 2.21

VERTICAL STRAIN INFLUENCE FUNCTION CARD

Variable	CC	Description
ZB(1)	1-10	The z/B value of the first coordinate point defining the vertical strain influence function, I_z. This value does not have to be at the base of the footing.
VIZ(1)	11-20	The strain influence function value, I_z, at the first coordinate point defining the vertical strain influence function.
ZB(2)	21-30	The z/B value of the intersection of the two lines defining the strain influence function.
VIZ(2)	31-40	The strain influence function value at the intersection of the two lines defining the strain influence function.
ZB(3)	41-50	The depth of influence (z/B ratio) of the strain influence function.
VIZ(3)	51-60	The strain influence function value at the depth of influence.

2.18 Meyerhof's Conversion Factors Card

Meyerhof's method is an empirical relationship that is units dependent. MAGSET assumes any consistent set of units. Therefore, when Meyerhof's method is used the units of the input data must convert to the units necessary for Meyerhof's equation.

This card inputs the conversion factors for the length units and the force units. This card is input only if IOPT(6) = 1 or 4.

Table 2.22 contains a list of commonly used units and the conversion factor to convert into units of feet and tons which are the units used by Meyerhof's equation.

TABLE 2.22a

LENGTH CONVERSION FACTORS

Length Unit of Input Data	Conversion Factor
feet	1.0
inches	0.0833333
centimeters	0.0328084
meters	3.2808399
cubits	≈ 1.5

TABLE 2.22b

FORCE CONVERSION FACTORS

Force Unit of Input Data	Conversion Factor
tons	1.0
kips	0.5
pounds	0.0005
grams	0.00000110231
kilograms	0.00110231
stones	0.007

The READ variables for Meyerhof's conversion factors are,

CONVFT, CONVTN

The FORMAT is,

2F10.0 Free Field

The READ variables are defined in Table 2.23.

TABLE 2.23

MEYERHOF'S CONVERSION FACTORS

Variable	CC	Description
CONVFT	1-10	Length conversion factor. This value is used to convert the length unit of the input data to units of feet.
CONVTN	11-20	Force conversion factor. This value is used to convert the force unit of the input data to units of tons.

2.19 D'Appolonia's Parameters Card

This card inputs the parameters in D'Appolonia's equation. This card is input only if IOPT(6) = 2 or 4. These parameters may be selected from the relations given in Figure 11.

The compressibility modulus M may be specified in two ways. In the first case the relationship between the modulus and the standard penetration test (SPT) blowcount (N) is specified by a straight line relationship. An intercept and slope coincident with the users knowledge of the stress history of the sand is input. When the average weighted blowcount is computed by the program this relationship is used to calculate a compressibility modulus.

The second way to specify the compressibility modulus is to input a value. This case exists when the average blowcount is known or assumed. The input value for the modulus is then used directly in D'Appolonia's equation and the blowcounts input to the program are ignored.

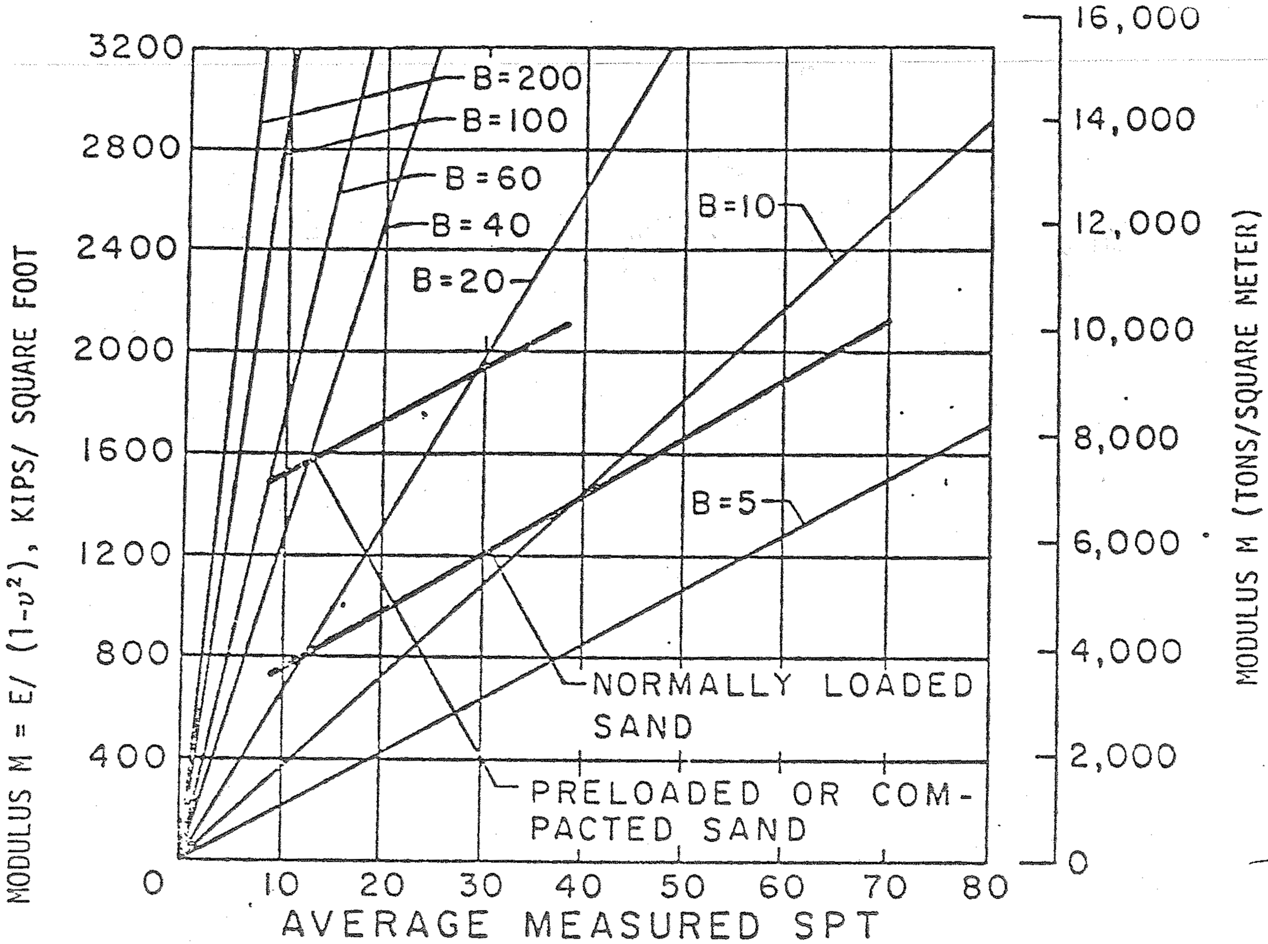
The READ variables for D'Appolonia's equation are,

U0, U1, EMOD, EINTCP, ESLOPE

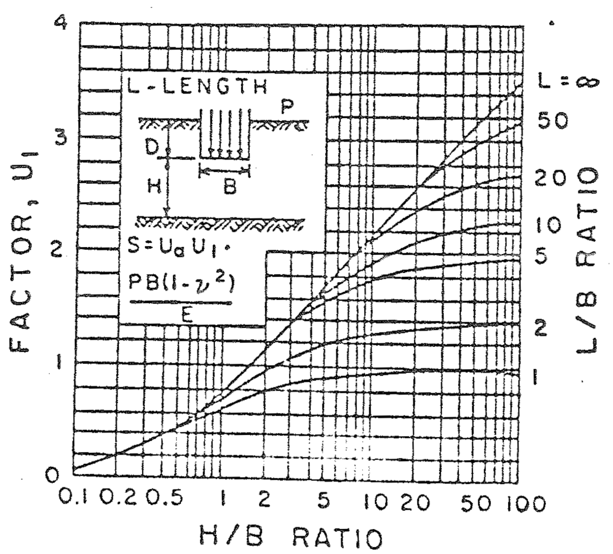
The FORMAT is,

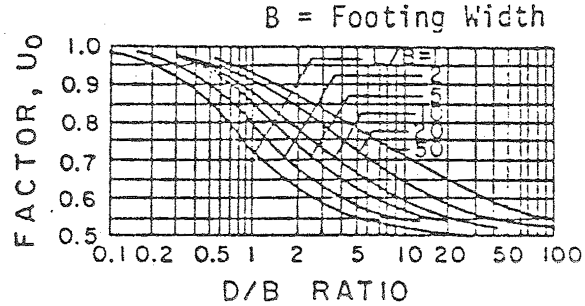
5F10.0 Free Field

The READ variables are defined in Table 2.24.



CORRELATION OF MODULUS VS. BLOWCOUNT





INFLUENCE FACTORS

Figure 11

D'APPOLONIA PARAMETERS

TABLE 2.24

D'APPOLONIA'S PARAMETERS CARD

Variable	CC	Description
U0	1-10	Embedment correction.
U1	11-20	Stratum thickness correction.
EMOD	21-30	Specified compressibility modulus (M). Leave this field blank if EINTCP and ESLOPE are specified.
EINTCP	31-40	Modulus intercept in relation between compressibility modus and (SPT) blowcount (N). Leave this field blank if EMOD is specified.
ESLOPE	41-50	Slope of the modulus-blowcount correlation. Leave this field blank if EMOD is specified.

Chapter 3 - SAMPLE PROBLEMS

This chapter describes seven sample problems for MAGSET-II, Version 1. The test problems illustrate the capabilities of the software and demonstrate the data input. In addition, the test problems extensively exercise the program's code.

The coded input for all the test problems is shown in Figure 19. The output is shown in Figure 20.

3.1 Sample Problem Number One

Sample problem 1 has a soil profile consiting of clay and sand layers as shown in Figure 12. It is desired to determine the magnitude of the consolidation settlements of the three clay layers. No sand settlements will be computed.

The effective stress history is due to the following construction sequence:

1) Unloading due to excavation
2) Preloading
3) Removal of part of the preload
4) Foundation loading

The insitu effective stress and the effective stress increments at the center of the clay layers are given in Table 3.1.

The clay layers have idealized void ratio-effective stress curves as shown in Figure 13. The deformation curves were input using coordinate points. The coordinates are given in Table 3.2. Units are specified in feet and tons.

The insitu effective stress for layer number 2 is shown as zero in the output because layer 2 is designated as incompressible and no insitu effective stress is required.

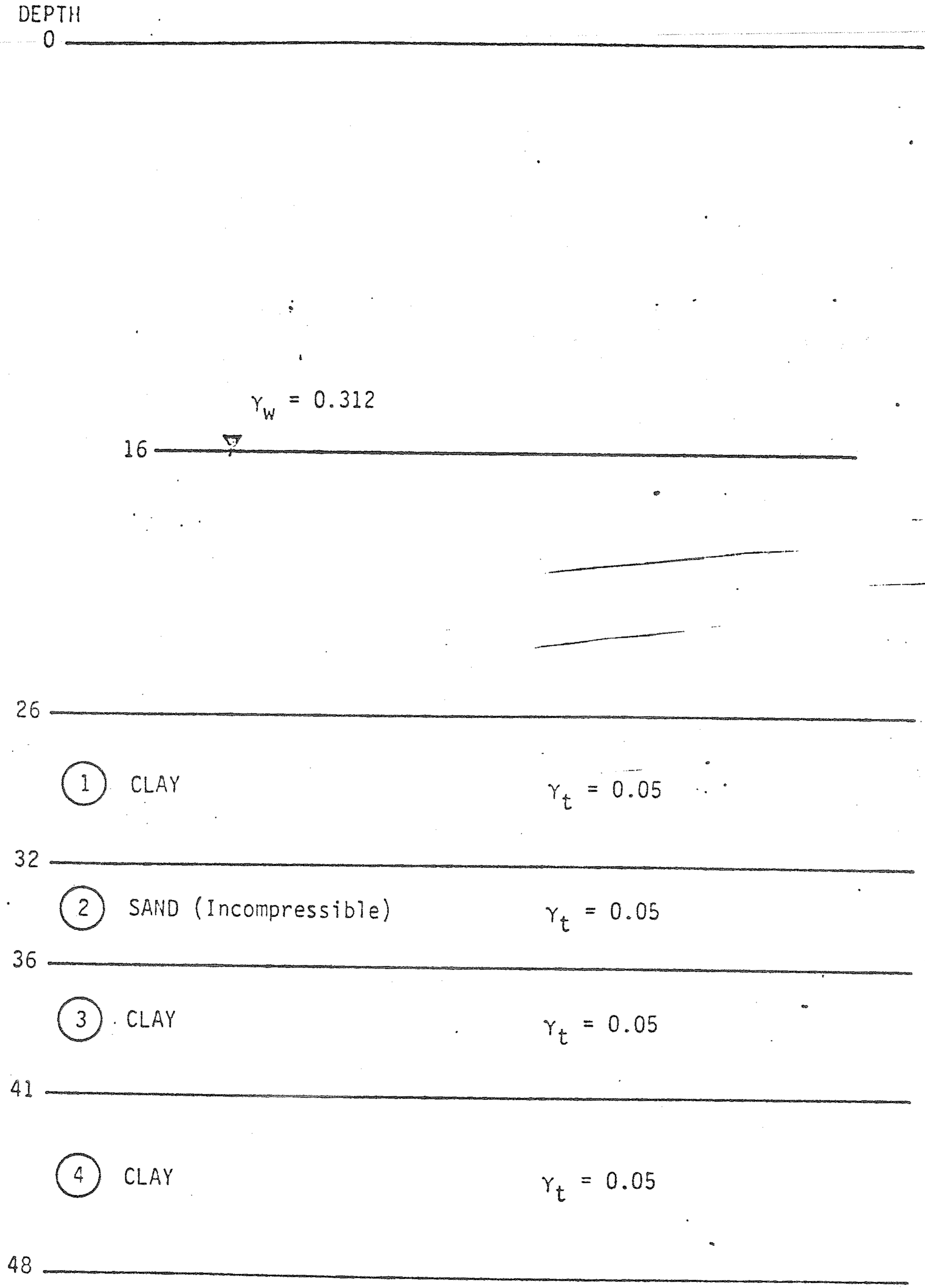


Figure 12
Soil Profile - Sample Problem 1

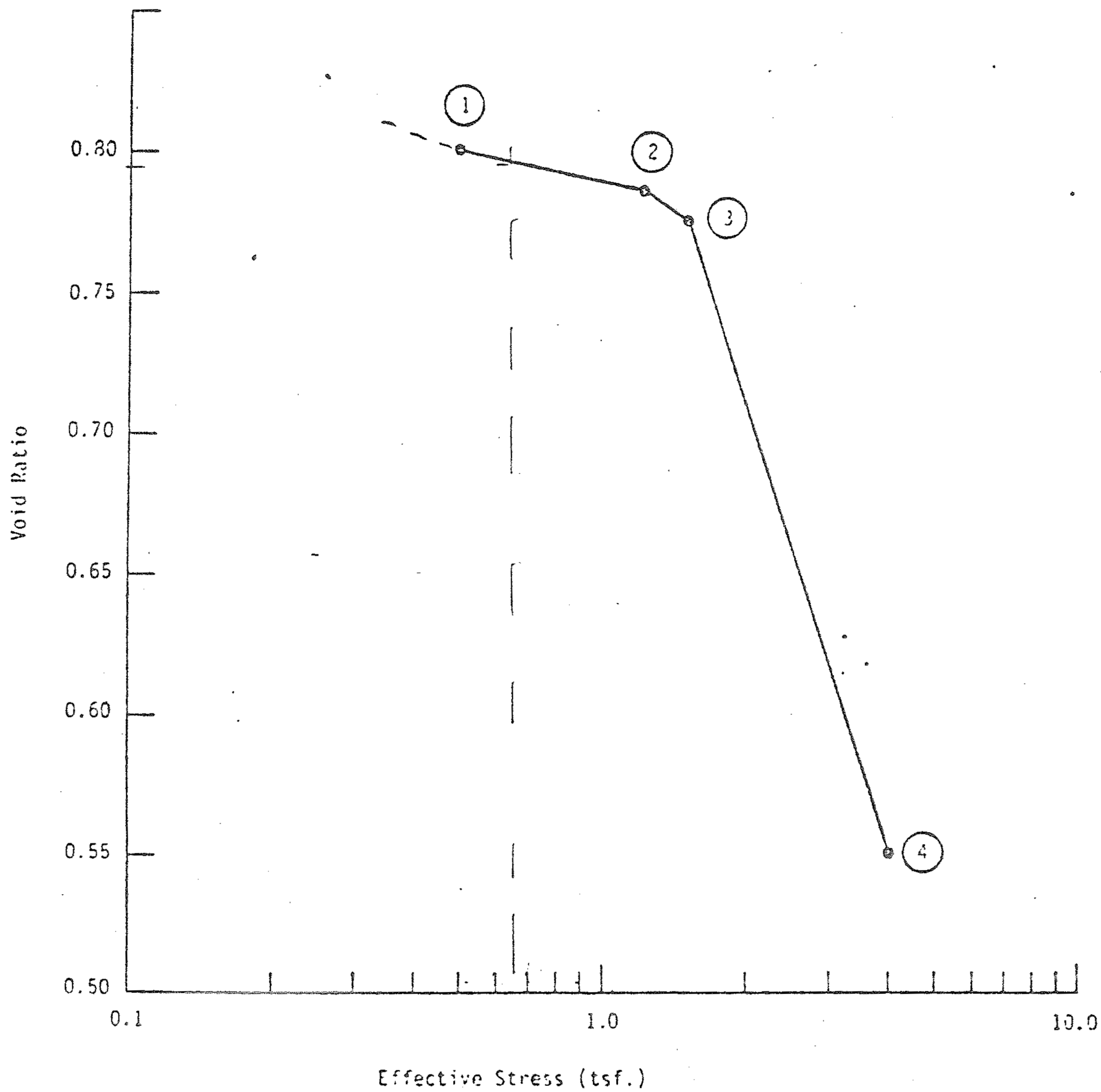


Figure 13a
Deformation Curve for Layer 1

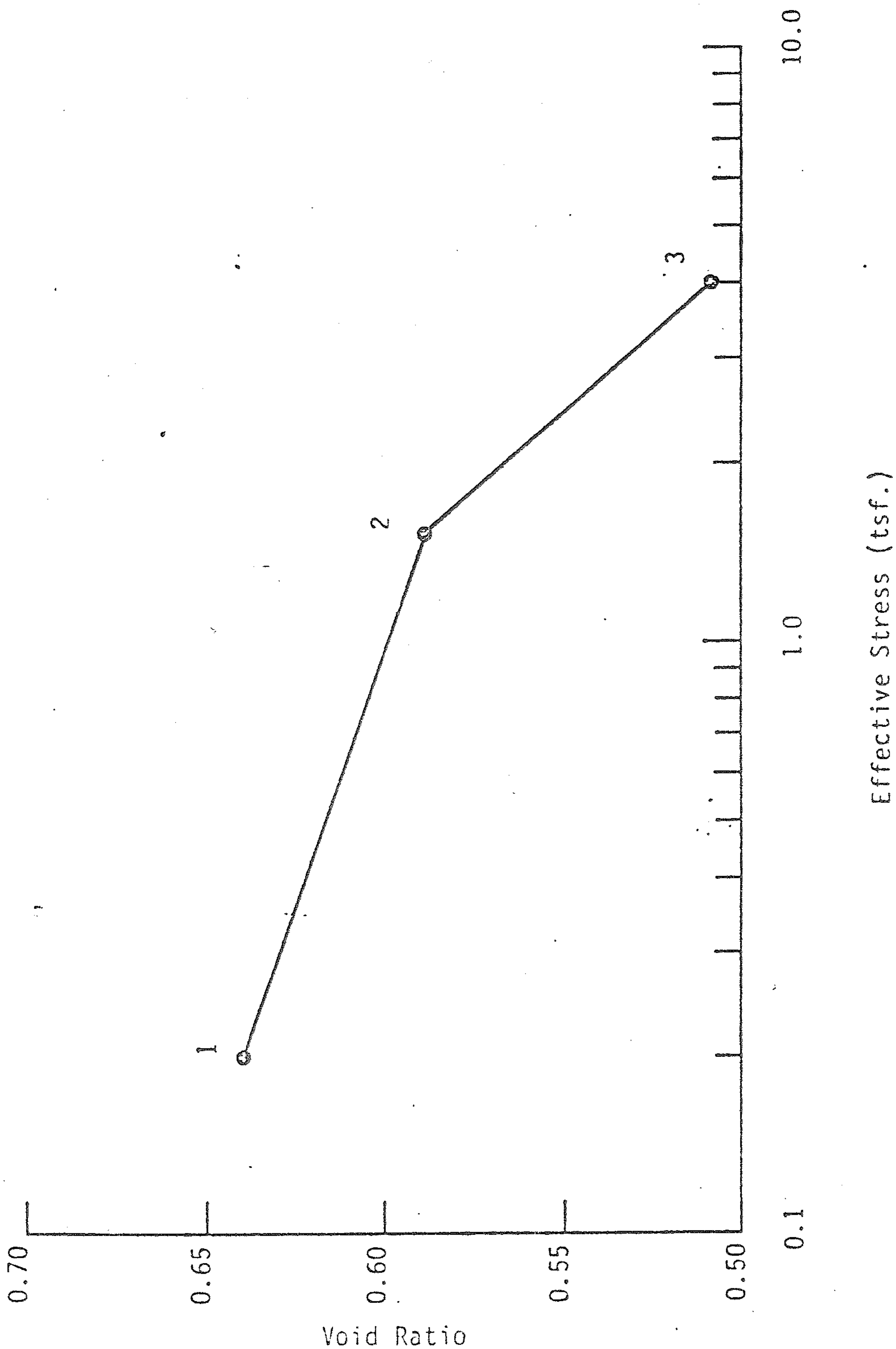


Figure 13b

Deformation Curve for Layer 3

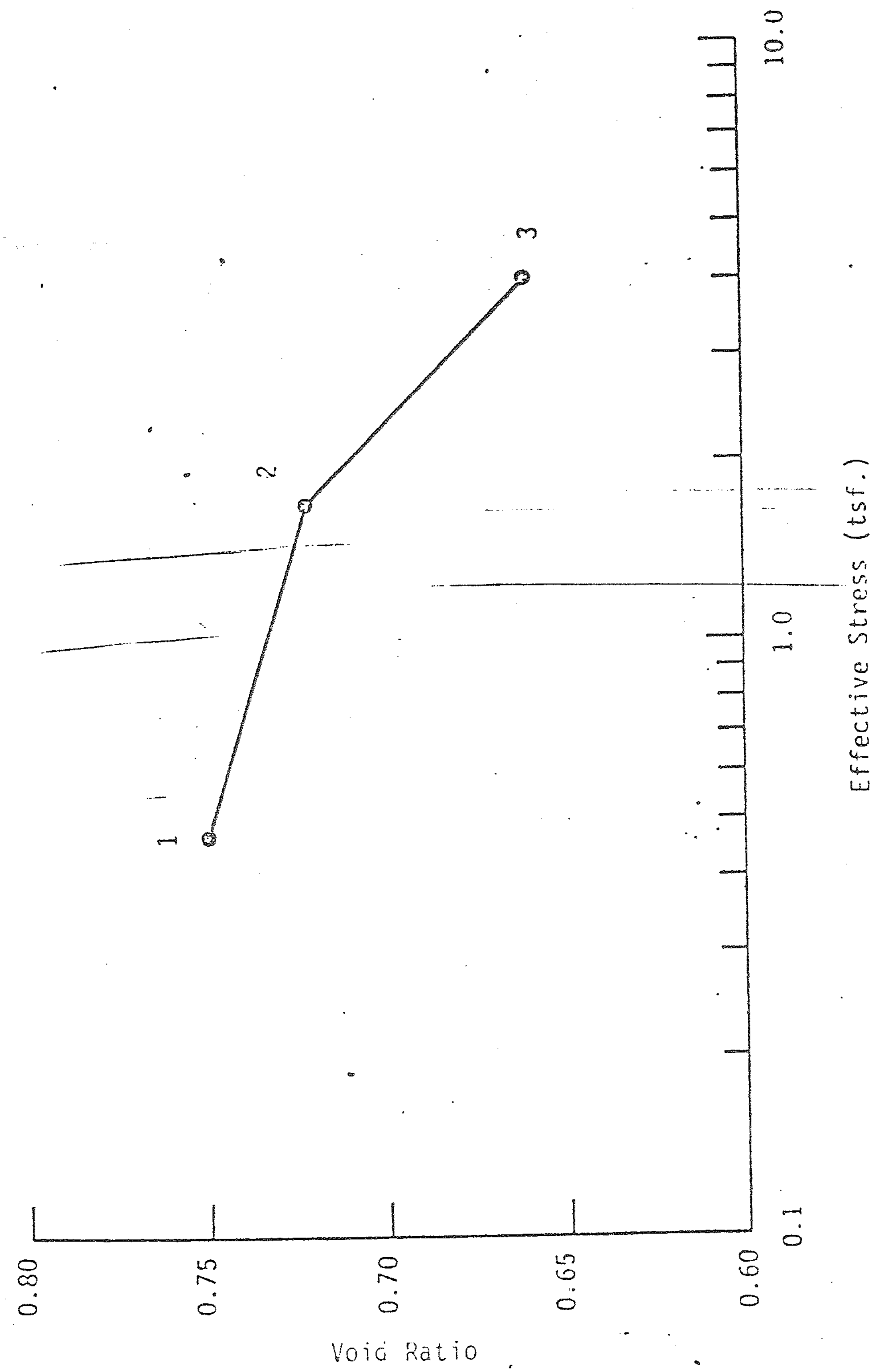


Figure 13c

Deformation Curve for Layer 4

TABLE 3.1

EFFECTIVE STRESS HISTORY - SAMPLE PROBLEM 1

Load Event	Layer 1		Layer 3		Layer 4	
	Δσ'	σ'	Δσ'	σ'	Δσ'	σ'
Insitu		1.219		1.51		1.688
Excavation	-0.6924	0.5266	-0.6600	0.8500	-0.6036	1.0844
Preload	0.7282	1.2548	0.6780	1.5280	0.4246	1.5090
Removal	-0.200	1.0548	-0.200	1.3280	-0.200	1.3090
Foundation	0.6898	1.7446	0.6194	1.9474	0.2858	1.5947

TABLE 3.2

COORDINATE POINTS ON THE DEFORMATION CURVE

Layer Number	Point Number	Void Ratio	Stress	Rebound Void Ratio	Rebound Stress
1	1	0.80	0.5		
1	2	0.785	1.219	0.80	0.5
1	3	0.775	1.5	0.7783	1.219
1	4	0.55	4.0	0.5967	1.5
3	1	0.64	0.2		
3	2	0.588	1.51	0.64	0.2
3	3	0.509	4.00	0.5250	1.51
4	1	0.80	0.475		
4	2	0.773	1.688	0.8	0.475
4	3	0.711	4.00	0.722	1.688

3.2 Sample Problem Number Two

Sample problem 2 analyzes the settlement of the soil profile beneath the center of the footing shown in Figure 14. An adjacent footing is also shown. The consolidation settlement will be calculated for the clay layers. Meyerhof's method will be used to compute settlements in the sand layers.

A foundation pressure of 2.2 kips/ft^2 will be applied to both footings in increments of .7, .75 and .75 kips/ft.^{2} The effective stress history for the clay layers in the soil profile is specified by using stress distribution functions. The stress distribution functions were independently determined by Westergaard's method. The contribution of the main footing and the additional stress imposed beneath the center of the main footing by the adjacent footing were added to determine the percentage of the footing load at the center of each layer. The stress increments for the stratum and the stress distribution functions are given in Table 3.3.

Insitu effective stress values were calculated by the program at the midpoint of each layer.

The deformation curves for the clay layers are specified using effective stress values, slopes, and reference points. The deformation curves are given as strain-effective stress curves. All the curves are specified with the reference coordinate at the preconsolidation pressure with the slopes specified above and below the preconsolidation pressure. These values are given in Table 3.4.

The sand settlements are calculated using Meyerhof's method. The penetration data is given in Table 3.5. The strain influence function given in curve "g" in Figure 7 is used to calculate the strain weighted blowcount. A foundation pressure of 4.5 kips/ft^2 and foundation width of 20.0 ft were used to calculate sand settlements.

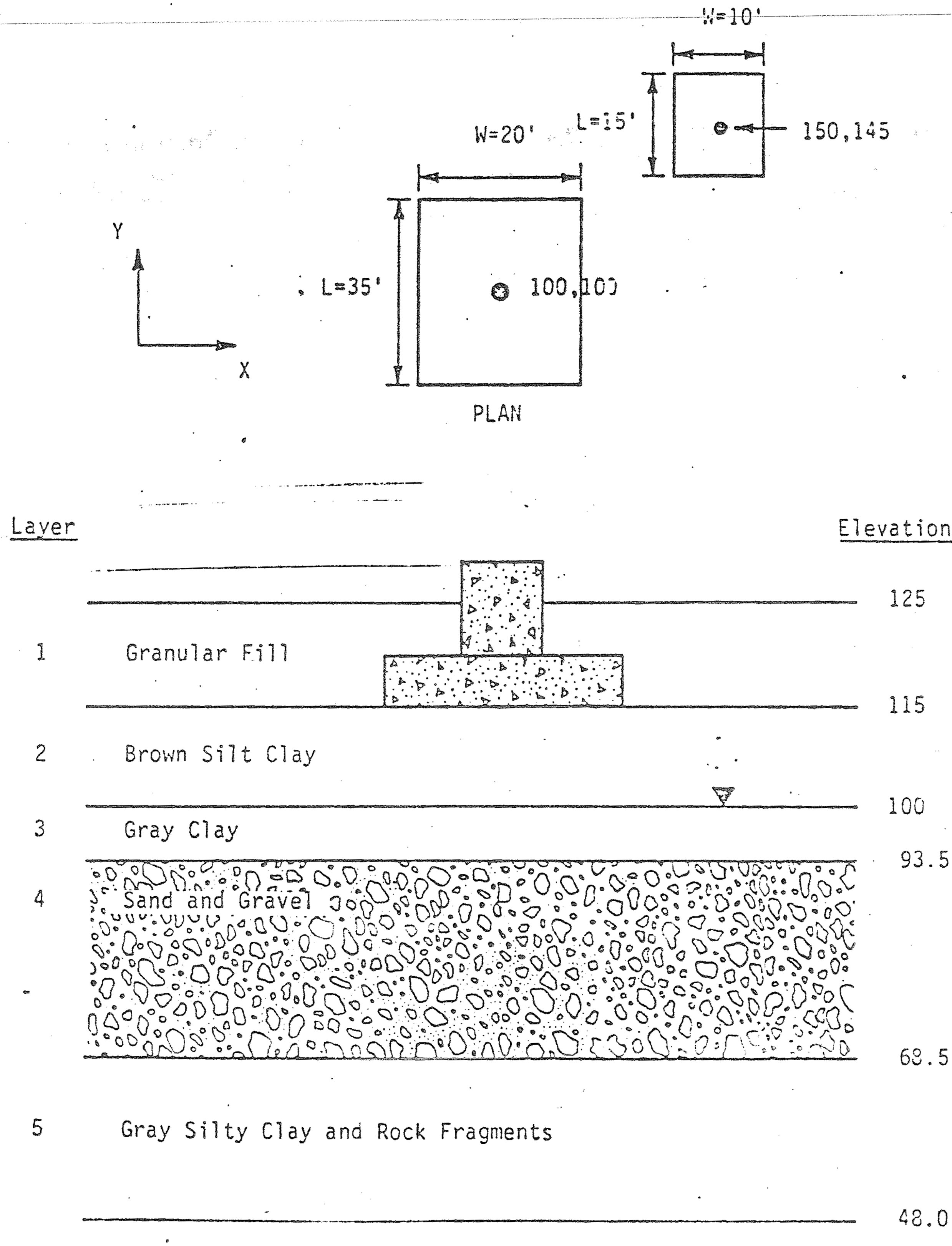


Figure 14
Plan and Profile - Sample Problem 2

TABLE 3.3a

STRESS INCREMENTS FOR STRATUM

Increment Number	Effective Stress Increment (kip/ft^2)
1	0.7
2	0.75
3	0.75

TABLE 3.3b

STRESS DISTRIBUTION FUNCTION

Layer Number	Stress Distribution Value
2	.64
3	.33
5	.06

TABLE 3.4a

DEFORMATION CURVE DATA - EFFECTIVE STRESS POINTS

Layer	Point	Effective Stress
2	1	0.1
2	2	5.4
2	3	10.0
3	1	0.1
3	2	3.2113
3	3	10.0
5	1	0.1
5	2	7.2
5	3	10.0

TABLE 3.4b

DEFORMATION CURVE DATA - REFERENCE POINTS

Layer	Point	Reference Strain	Reference Effective Stress
2	2	0.0026	5.4
3	2	0.0	3.2113
5	2	0.0015	7.2

TABLE 3.4c

DEFORMATION CURVE DATA - SLOPES

Layer	Line Number	Compression Slope	Expansion Slope
2	1	0.0062	0.00625
2	2	0.0625	0.00625
3	1	0.0131	0.0131
3	2	0.1333	0.0133
5	1	0.0171	0.0171
5	2	0.1765	0.01765

TABLE 3.5

SOIL PROPERTIES - SAMPLE PROBLEM 3

Layer	Soil Type	Total Unit Weight (kips/ft^3)	S.P.T. Blowcount	Static Cone Penetration Resistance (kips/ft^2)
1	Sand	0.115	10.0	80.0
2	Sand	0.115	12.0	96.0
3	Sand	0.1154	15.0	120.0

The input elevations are converted to datum elevations using a benchmark elevation of 1000.0 ft and an elevation difference of 0.0 ft.

3.3 Sample Problem Number Three

Sample problem 3 analyzes the settlement of the sand profile shown in Figure 15. The settlements are computed using all three sand settlement methods: Meyerhof, D'Appolonia, and Schmertmann.

The soil properties are given in Table 3.5.

The strain influence function, curve "g," is used in the strain and strain weighted blowcount calculations.

The intercept and slope for D'Appolonia's relation between compressibility modulus and blowcount are input as 533.0 kips/ft^2 and 22.2 kips/ft^2, respectively.

The settlements were calculated using a footing width of 10.0 ft and a footing pressure of 3.0 kips/ft^2.

Caution should be exercised when comparing the results of Meyerhof, D'Appolonia and Schmertmann on a single problem. The methods are based on different empirical correlations. In addition, the following should be considered prior to making comparisons:

(1) Each of the methods utilizes different factors to account for the effects of embedment.

(2) The q_c/N correlations published by Schmertmann are a tempting vehicle to jump between static cone penetration and S.P.T. blowcount. However, the author presented this relation as a temporary expedient which is conservative when converting from N to q_c and it should be used judiciously.

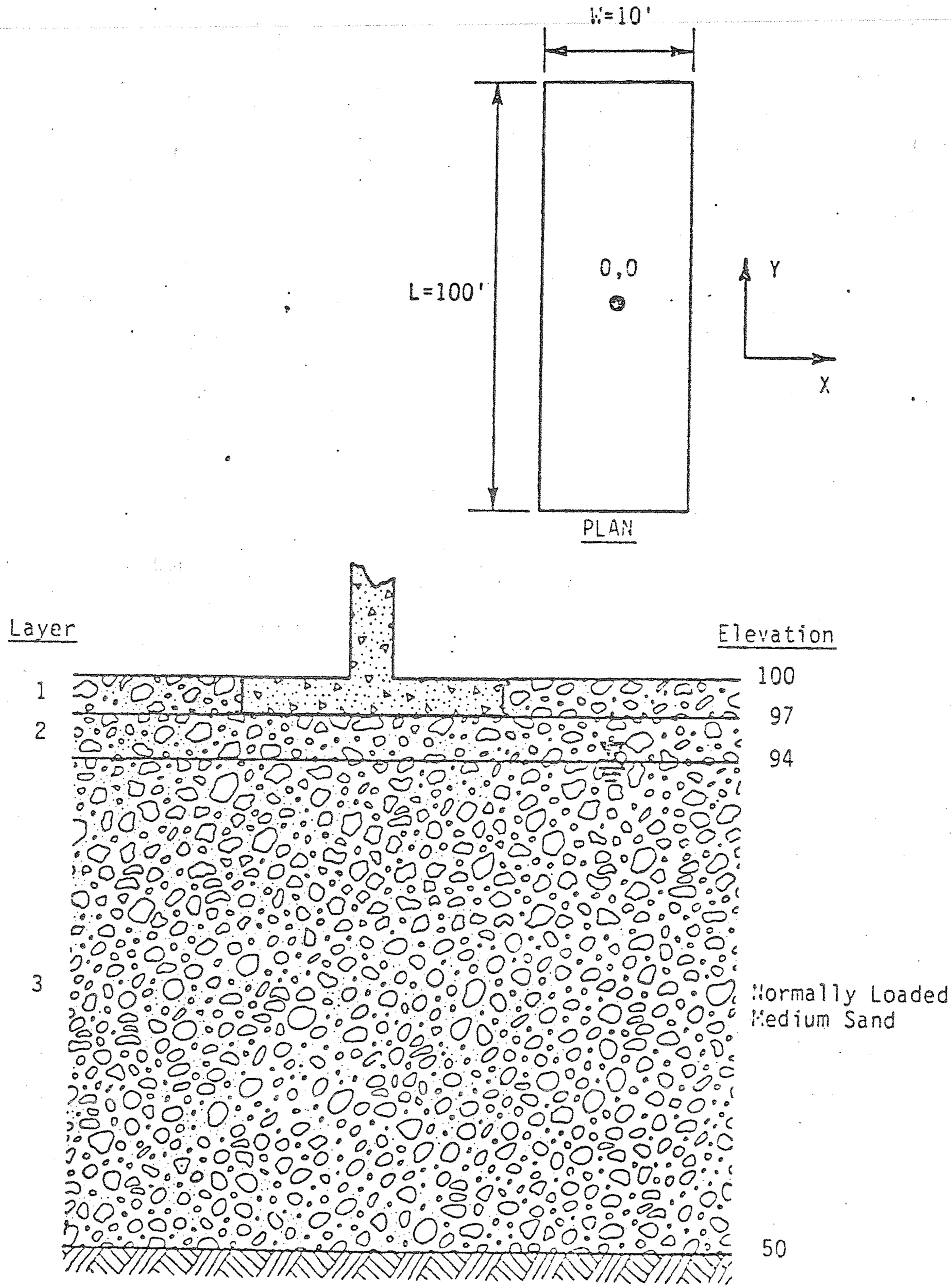


Figure 15

Plan and Profile - Sample Problem 3

(3) The concept of a strain function is used differently by the methods. Meyerhof's and D'Appolonia's methods were developed for homogeneous granular soil profiles. These methods use the strain function concept to arrive at an average strain weighted blowcount of an "ideal" homogeneous soil profile. The settlements for Meyerhof's and D'Appolonia's methods are then obtained using this average strain weighted blowcount.

Schmertmann's method uses the function to obtain the magnitude of settlement by an integration of strains.

3.4 Sample Problem Number Four

Sample problem 4 is identical to sample problem 3 except the strain influence function, curve "f," was used in the strain and strain weighted blowcount calculations.

3.5 Sample Problem Number Five

This problem is an example problem given in the reference by Schmertmann (1970). The compressible stratum consists of sand layers as shown in Figure 16. Settlements are calculated using Schmertmann's method and the strain influence function, curve "f."

The soil properties are given in Table 3.6.

The settlements were calculated using a foundation pressure of 1.82 kg/cm^2 and a foundation width of 260.0 cm. The results of this problem do not include the effects of creep which were calculated by Schmertmann (1970).

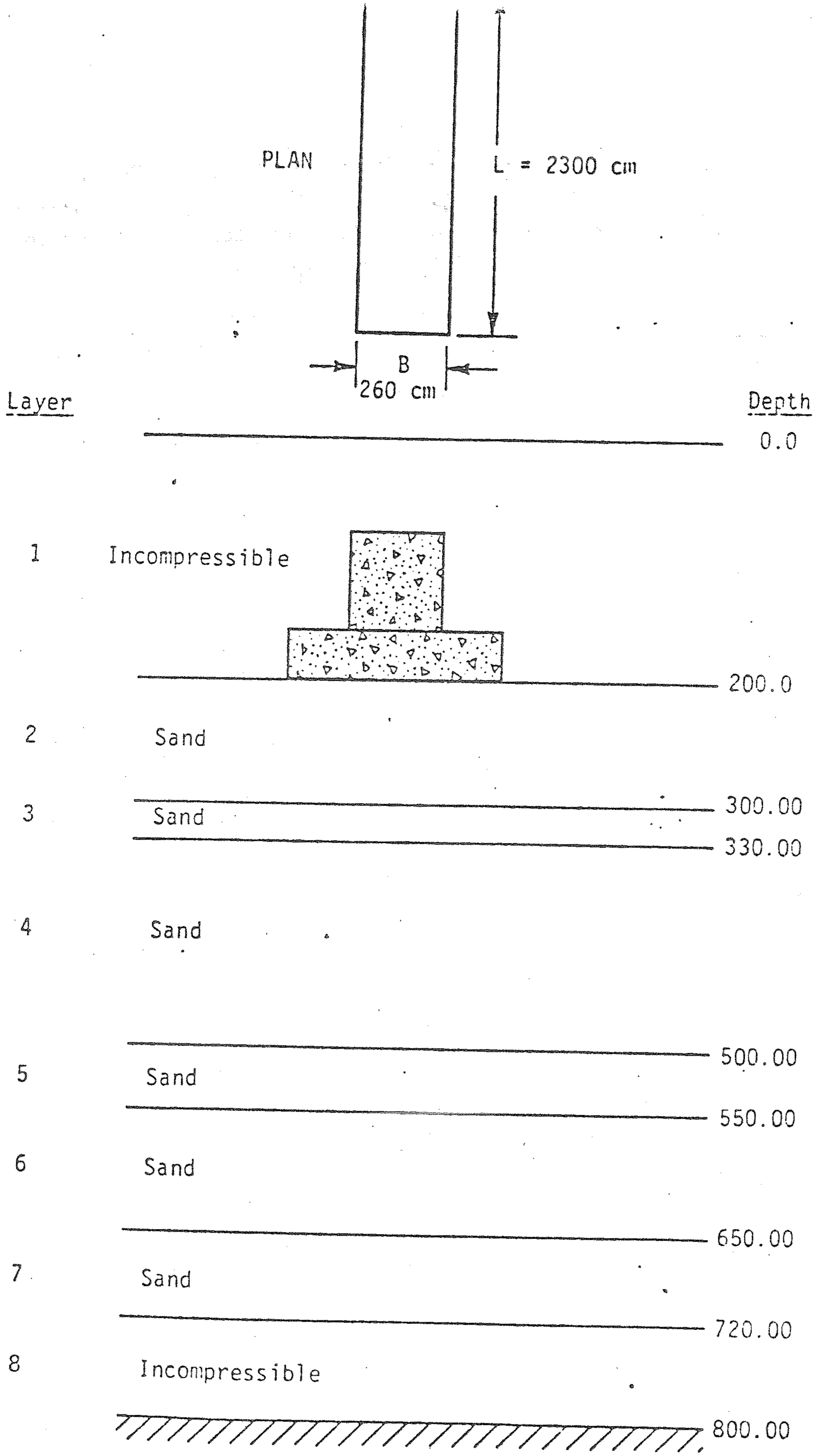


FIGURE 16
SOIL PROFILE - SAMPLE PROBLEM 5 and 6

TABLE 3.6

SOIL PROPERTIES - SAMPLE PROBLEM 5

Layer	Soil Type	Total Unit Weight (kg/cm^3)	Static Cone Penetration Resistance (kg/cm^2)
1	Incompressible	0.0016	--
2	Sand	0.002	25.0
3	Sand	0.002	35.0
4	Sand	0.002	35.0
5	Sand	0.002	70.0
6	Sand	0.002	30.0
7	Sand	0.002	85.0
8	Incompressible	0.002	--

3.6 Sample Problem Number Six

Sample problem 6 analyzes the same soil profile as sample problem 5 (Figure 16). Settlements are calculated using D'Appolonia's method with an input strain influence function. The foundation pressure and foundation width from sample problem 5 are used.

The slope of D'Appolonia's compressibility relation is input as 10.0 with an intercept of 250.0.

The strain influence function input is from the example strain influence function in Section 2.17 (Table 2.20).

A ratio of q_c/N of 4.0 was used to convert the static cone penetration resistance in sample problem 5 to standard penetration test blowcounts. The significant digits beyond the decimal point shown in Table 3.7 are retained for this reason.

TABLE 3.7

S.P.T. BLOWCOUNT DATA - SAMPLE PROBLEM 6

Layer	S.P.T. Blowcount
2	6.25
3	8.75
4	8.75
5	17.5
6	7.50
7	21.25

3.7 Sample Problem Number Seven

Sample problem 7 analyzes the consolidation settlement of a clay layer that is 18.0 ft. thick. The problem was modeled by dividing the 18.0 ft. thick stratum into four layers each 4.5 ft. thick.

The effective stress history was determined with the aid of a computer program which calculates the time dependent dissipation of excess pore pressure. From this solution the effective stress increments in each layer were determined at discrete time values. Table 3.8 gives the insitu effective stress and the effective stress increments in each layer.

The void ratio-effective stress curve shown in Figure 17 is an idealized curve that is used to compute settlements in the clay layers.

Units are in feet and kips.

The input depths were converted to datum elevations. The datum elevation for the problem is 41.16. The benchmark is located 22.73 feet above the ground surface.

TABLE 3.8

EFFECTIVE STRESS HISTORY - SAMPLE PROBLEM 7

Stress Increment ($\Delta\sigma'$)	Layer 1	Layer 2	Layer 3	Layer 4
Insitu	4.67	5.02	5.38	5.74
1	-0.3	-0.9	-2.0	-2.7
2	0.4	0.4	1.0	1.1
3	0.4	0.5	0.5	0.2
4	0.9	0.8	0.7	0.9
5	3.3	3.2	3.5	3.6
6	0.8	0.8	0.6	0.5
7	0.6	0.6	0.6	0.6
8	-0.6	-0.1	0.2	0.8

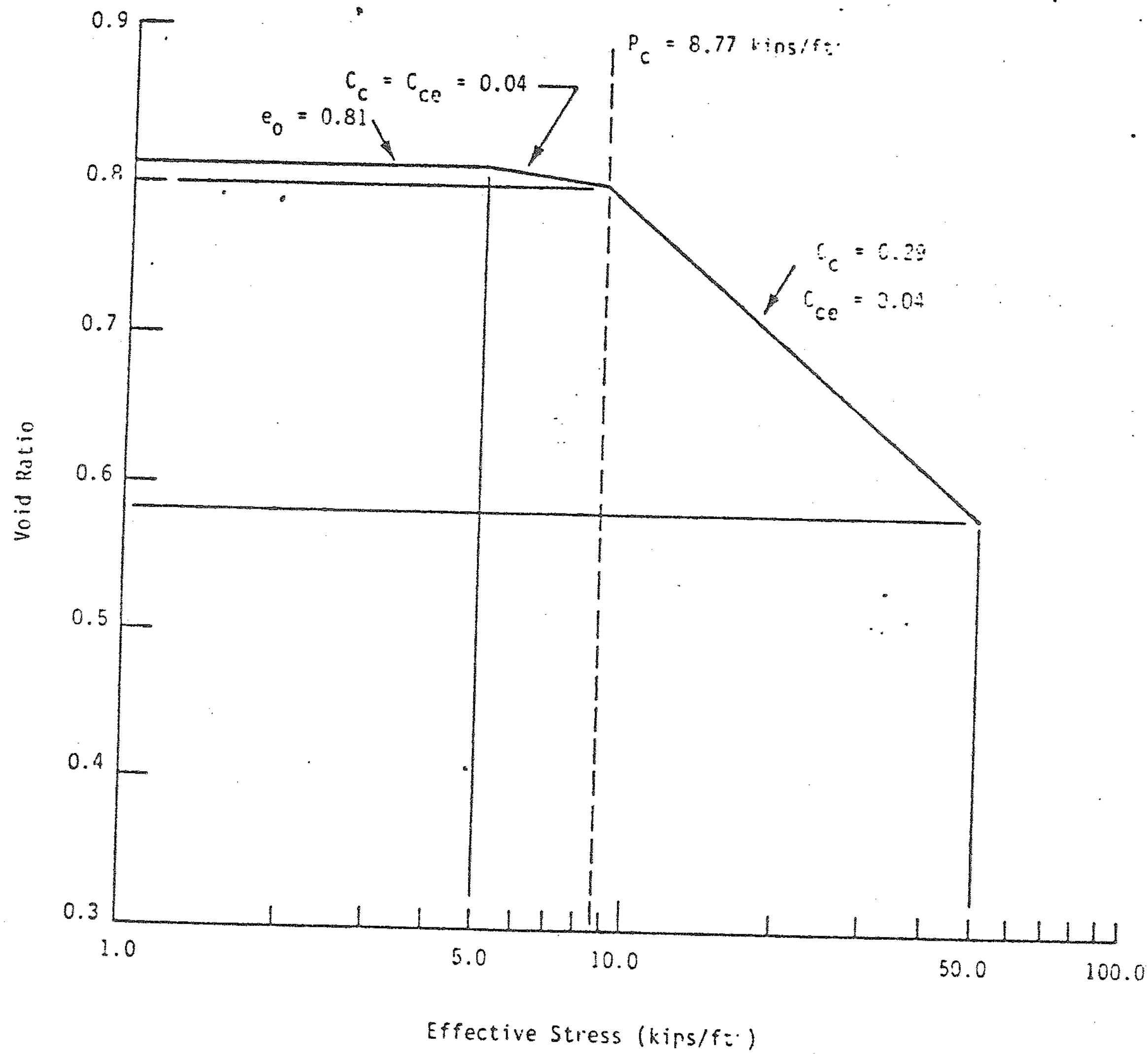


Figure 17
Deformation Curve - Sample Problem 7

Sample Problems

```
         1         2         3         4
1234567890123456789012345678901234567890
 1     1    4
 2                               SAMPLE PROBLEM NUMBER ONE
 3     1    2    1    2    1    0    0    1
 4       FEET           TONS
 5   0.0312    16.0
 6     1       26.0
 7     2       32.0
 8     3       36.0
 9     4       41.0
10     5       48.0
11     1    1   0.05
12     2    3   0.05
13     3    1   0.05
14     4    1   0.05
15     1        1.219
16     2        0
17     3        1.51
18     4        1.688
19     1       -0.6924   0
```

FIGURE 19a
DATA INPUT
SAMPLE PROBLEMS

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20	1		0.7282	0			
21	1		-0.2	0			
22	1		0.6898	1			
23	3		-0.66	0			
24	3		0.678	0			
25	3		-0.2	0			
26	3		0.6194	1			
27	4		-0.6036	0			
28	4		0.4246	0			
29	4		-0.2	0			
30	4		0.2858	1			
	1	1	0.8	0.5			
	1	2	0.765	1.219	0.8	0.5	0
	1	3	0.775	1.5	0.77833	1.219	0
	1	4	0.56	4.0	0.5967	1.5	1
	3	1	0.64	0.2			~~0~~
	3	2	0.588	1.51	0.64	0.2	0
	3	3	0.509	4.0	0.525	1.51	1
	4	1	0.8	0.475			

FIGURE 19b

DATA INPUT

SAMPLE PROBLEMS

4	2	0.773		1.688		0.8		0.475		0
4	3	0.711		4.0		0.722		1.688		1
2	5	1								
	Layers				SAMPLE PROBLEM NUMBER TWO					
1	1	3	1	2	1	1	2			
	FEET			KIPS						
0.0624		100.0								
1		125.0								
2		115.0								
3		100.0								
4		93.5								
5		68.5								
6		48.0								
1	2	0.120								
2	1	0.120								
3	1	0.1274								
4	2	0.1324								
5	1	0.1324								
1000.0		0.0								

FIGURE 19c
DATA INPUT
SAMPLE PROBLEMS

GEOTECHNICAL ENGINEERING SOFTWARE ACTIVITY
UNIVERSITY OF COLORADO COMPUTING CENTER
Boulder, Colorado 80302

	Cols 1–5	Cols 6–10	Cols 11–20	Cols 21–30
	0.7		0	
	0.75		0	
	0.75		1	
	2		0.64	
	3		0.33	
	5		0.06	
	2	1	0.1	0
	2	2	5.4	0
2.14 a	2	3	10.0	1
b	2	2	0.00256	5.4
c	2	1	0.00625	0.00625
e	2	2	0.0625	0.00625
	3	1	0.1	0
	3	2	3.2113	0
	3	3	10.0	1
	3	2	0.0	3.2113
	3	1	0.0131	0.0131
	3	2	0.1333	0.01333
	5	1	0.1	0

FIGURE 19d

DATA INPUT

SAMPLE PROBLEMS

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Boulder Colorado 80302


```
1234567890123456789012345678901234567890123456789012345678901234567890123456789
    5    2  7.2         0
    5    3 10.0         1
    5    2  0.0015    7.2
    5    1  0.0171    0.0171
    5    2  0.1765    0.01765
    1      20.0
    4      45.0
  4.5      20.0        115.0
  1.0       0.5
    3    3    1
                         SAMPLE PROBLEM NUMBER THREE
    1    1    0    0    0    4    1    1
      FEET      KIPS
 0.0624     94.0
    1      100.0
    2       97.0
    3       94.0
    4       50.0
    1    2   0.115
```

FIGURE 19e

DATA INPUT

SAMPLE PROBLEMS

GEOTECHNICAL ENGINEERING SOFTWARE ACTIVITY
UNIVERSITY OF COLORADO COMPUTING CENTER
Boulder, Colorado 80302


```
    2    2   0.115
    3    2   0.1154
    1       10.0         80.0
    2       12.0         96.0
    3       15.0        120.0
  3.0       10.0         97.0
  1.0        0.5
 0.97        1.65           0          533.0          22.2
    4    3   1.
                                  SAMPLE PROBLEM NUMBER FOUR
    1    3    0    0    0    4    2    1
    FEET                KIPS
0.0624       94.0
    1       100.0
    2        97.0
    3        94.0
    4        50.0
    1    2    0.115
    2    2    0.115
```

FIGURE 19f
DATA INPUT
SAMPLE PROBLEMS

GEOTECHNICAL ENGINEERING SOFTWARE ACTIVITY
UNIVERSITY OF COLORADO COMPUTING CENTER
Boulder, Colorado 80302


```
    3     2     0.1154
    1           0.1
    2           0.05
    3           0.025
    1          10.0        80.0
    2          12.0        96.0
    3          15.0       120.0
  3.0          10.0        97.0
  1.0           0.5
 97.0           1.65        0         533.0       22.2
    5     8     6
                              SAMPLE PROBLEM NUMBER FIVE
    1     1     0     0     0     3     2     1
CENTIMETERS           KILOGRAMS
0.001     1000.
    1           0.0
    2         200.0
    3         300.0
    4         330.0
```

FIGURE 19g

DATA INPUT

SAMPLE PROBLEMS

Layer type weights

Cols 1–5	Cols 6–10	Cols 11–20	Cols 21–30
5		500.0	
6		550.0	
7		650.0	
8		720.0	
9		300.0	
1	3	0.0016	
2	2	0.002	
3	2	0.002	
4	2	0.002	
5	2	0.002	
6	2	0.002	
7	3	0.002	
8	3	0.002	
2		0	25.0
3		0	35.0
4		0	35.0
5		0	70.0
6		0	30.0
7		0	35.0

FIGURE 19h

DATA INPUT

SAMPLE PROBLEMS

GEOTECHNICAL ENGINEERING SOFTWARE ACTIVITY
UNIVERSITY OF COLORADO COMPUTING CENTER
Boulder, Colorado 80302

FP, FB, Depth

```
1.82      260.0     200.0
6         8
                             SAMPLE PROBLEM NUMBER SIX
2         1         0         0         0         2         3         1
0.001 : 1000.0
1              0.0
2            200.0
3            300.0
4            330.0
5            500.0
6            550.0
7            650.0
8            720.0
9            800.0
1         3         0.0016
2         2         0.002
3         2         0.002
4         2         0.002
5         2         0.002
```

FIGURE 19i

DATA INPUT

SAMPLE PROBLEMS

GEOTECHNICAL ENGINEERING SOFTWARE ACTIVITY
UNIVERSITY OF COLORADO COMPUTING CENTER
Boulder Colorado 80302


```
6    2    0.002
7    2    0.002
8    2    0.002
2         6.25      0
3         8.75      0
4         8.75      0
5         17.5      0
6         7.5       0
7         21.25     0
1.82      260.0     200.0
0.0       0.2       0.375     0.7       2.0       0.0
0.75      2.2       0         250.0     10.0
7    4    1
                    SAMPLE PROBLEM NUMBER SEVEN
1    2    1    2    2    0    0    2
FEET           KIPS
0.0624    0.0
1         0.0
2         4.6
```

FIGURE 19j
DATA INPUT
SAMPLE PROBLEMS

	3		9.0		
	4		13.5		
	5		18.0		
	1	1		0	
	2	1		0	
	3	1		0	
	4	1		0	
datum 3-29	41.16		-22.73		
L, SINS1	1		4.67		
	2		5.02		
	3		5.38		
	4		5.74		
L, SIGMA, LS	1		-0.3		0
	1		0.4		0
	1		0.4		0
	1		0.9		0
	1		3.3		0
	1		0.8		0
	1		0.6		0

FIGURE 19k
DATA INPUT
SAMPLE PROBLEMS

GEOTECHNICAL ENGINEERING SOFTWARE ACTIVITY
UNIVERSITY OF COLORADO COMPUTING CENTER
Boulder, Colorado 80302

1	-0.6	1
2	-0.9	0
2	0.4	0
2	0.5	0
2	0.8	0
2	3.2	0
2	0.8	0
2	0.6	0
2	-0.1	1
3	-2.0	0
3	1.0	0
3	0.5	0
3	0.7	0
3	3.6	0
3	0.6	0
3	0.6	0
3	0.2	1
4	-2.7	0
4	1.1	0

FIGURE 191
DATA INPUT
SAMPLE PROBLEMS

GEOTECHNICAL ENGINEERING SOFTWARE ACTIVITY
UNIVERSITY OF COLORADO COMPUTING CENTER
Boulder, Colorado 80302

Col. 1–5	Col. 6–10	Col. 11–20	Col. 21–30
4		0.2	0
4		0.9	0
4		3.6	0
4		0.5	0
4		0.6	0
4		0.8	1
1	1	2.0	0
1	2	5.0	0
1	3	8.77	0
1	4	50.0	1
1	1	0.81	2.0
1	1	0.0	0.0
1	2	0.04	0.04
1	3	0.29	0.04
2	1	2.0	0
2	2	5.0	0
2	3	8.77	0
2	4	50.0	1
2	2	0.81	5.0

2.14a

FIGURE 19m
DATA INPUT
SAMPLE PROBLEMS

GEOTECHNICAL ENGINEERING SOFTWARE ACTIVITY
UNIVERSITY OF COLORADO COMPUTING CENTER
Boulder, Colorado 80302

2	1	0.0	0.0
2	2	0.04	0.04
2	3	0.29	0.04
3	1	2.0	0
3	2	5.0	0
3	3	8.77	0
3	4	50.0	1
3	2	0.81	5.0
3	1	0.0	0.0
3	2	0.04	0.04
3	3	0.29	0.04
4	1	2.0	0
4	2	5.0	0
4	3	8.77	0
4	4	50.0	1
4	4	0.681	50.0
4	1	0.0	0.0
4	2	0.04	0.04
4	3	0.29	0.04

FIGURE 19n
DATA INPUT
SAMPLE PROBLEMS

Chapter 4 - OUTPUT

The output from a successfully executed MAGSET 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.

4.1 Problem Specifications

Printed under this heading are the program header, title, and units.

4.2 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 ground water information, the unit weight of water, the depth or elevation of the ground water table, and the datum elevation of the ground water.

4.3 Insitu Effective Stress

Under this heading are the input and calculated insitu effective stresses in each layer and the insitu effective stress used by the program.

4.4 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 is printed along with any data calculated that defines the deformation curve. If void ratio-effective stress curves are input the compression and expansion indexes, C_c and C_e, are output along with the strain compression and strain expansion indexes, $C_{c\varepsilon}$ and $C_{e\varepsilon}$. If strain-effective stress curves are input only the strain compression and strain expansion slopes are output.

4.5 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.

4.6 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.

4.7 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 E2 - E1.

4.8 Sand Settlements

The settlements in each sand layer are printed by method. The total sand settlement over the sand profile is printed along with the total clay settlement and total profile settlement.

4.9 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. However, if confusion results, refer back to Chapters 1 and 2 under the appropriate sections.

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

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

***** TITLE *****
SAMPLE PROBLEM NUMBER ONE

***** UNITS *****

LENGTH	FORCE
FEET	TONS

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

LAYER NUMBER	SOIL TYPE	INTERFACE DEPTH	DATUM ELEVATIONS	THICKNESS	UNIT WEIGHT
		26.00	-		
1	CLAY			6.00	.0500
		32.00	-		
2	INCOMP			4.00	.0500
		36.00	-		
3	CLAY			5.00	.0500
		41.00	-		
	CLAY			7.00	.1000
		48.00	-		

UNIT WEIGHT OF WATER	GROUND WATER LEVEL	GROUND WATER DATUM ELEVATION
.0312	16.00	-

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

LAYER NUMBER	INPUT VALUE	CALCULATED VALUE	INSITU STRESS
1	1.2190	-	1.2190
2	-0.0000	-	0.0000
3	1.5100	-	1.5100
4	1.6880	-	1.6980

FIGURE 20a
OUTPUT
SAMPLE PROBLEM 1

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

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

LAYER NO.	PT. NO.	STRESS INCREMENT	STRESS VALUES
1	1	-.6924	.5266
1	2	.7282	1.2548
1	3	-.2000	1.0548
1	4	.6898	1.7446
3	1	-.6600	.8500
3	2	.6780	1.5280
3	3	-.2000	1.3280
3	4	.6194	1.9474
4	1	-.6036	1.0844
4	2	.4246	1.5090
4	3	-.2000	1.3090
4	4	.2858	1.5948

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
1	1	.8000	.5000		
1	2	.7850	1.2190	.8000	.5000
1	3	.7750	1.5000	.7783	1.2190
1	4	.5500	4.0000	.5967	1.5000
	1	.6400	.2000		
	2	.5880	1.5100	.6400	.2000
3	3	.5090	4.0000	.5250	1.5100
4	1	.8000	.4750		
4	2	.7730	1.6880	.8000	.4750
4	3	.7110	4.0000	.7220	1.6880

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

LAYER NUMBER	LINE NUMBER	CC	CE	CC (STRAIN)	CE (STRAIN)
1	1	.0388	.0388	.0215	.0215
1	2	.1110	.0370	.0622	.0207
1	3	.5282	.1096	.2976	.0618
3	1	.0592	.0592	.0361	.0361
3	2	.1867	.0378	.1176	.0238
4	1	.0490	.0490	.0272	.0272
4	2	.1655	.0294	.0933	.0166

****
ETTLEMENT CONTRIBUTIONS *
****

Figure 20a

OUTPUT

SAMPLE PROBLEM

***** SETTLEMENT BY LAYERS *****

LAYER NUMBER	STRESS INTERVAL	INCREMENTAL SETTLEMENT

	LAYER HISTORY				.1500[illegible]
3	1	TO	2		-.04654
3	2	TO	3		.04957
3	3	TO	4		-.00725
3	4	TO	5		.06918
3	LAYER HISTORY				.06495
4	1	TO	2		-.03720
4	2	TO	3		.02779
4	3	TO	4		-.01195
4	4	TO	5		.01660
4	LAYER HISTORY				-.00477

***** SETTLEMENT BY STRESS INTERVAL *****

STRESS INTERVAL			SETTLEMENT OVER PROFILE
1	TO	2	-.13123
2	TO	3	.12952
3	TO	4	-.02858
4	TO	5	.24056

TOTAL CLAY SETTLEMENT .21027

****
CLAY COMPRESSIBILITIES *
****

ER	STRESS			MV	DELTA E	E1	E2
	1	TO	2	.01143	-.01413	.78500	.7991
	2	TO	3	.01185	.01552	.79913	.7836
	3	TO	4	.00781	-.00279	.78360	.7863
	4	TO	5	.03737	.04604	.78639	.7403
	1	TO	2	.01410	-.01478	.53800	.6027
	2	TO	3	.01449	.01574	.60278	.5870
	3	TO	4	.00726	-.00230	.58704	.5893
	4	TO	5	.02232	.02197	.58934	.5673
	1	TO	2	.00880	-.00942	.77300	.7824
	2	TO	3	.00930	.00704	.78242	.7753
	3	TO	4	.00853	-.00303	.77539	.7794
	4	TO	5	.00827	.00421	.77841	.7742

THERE ARE NO SAND LAYERS IN THE SOIL PROFILE

Figure 20a
OUTPUT
SAMPLE PROBLEM

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

```
*********************
SPECIFICATIONS FOR *
  PROBLEM NO.  2   *
*********************
```

***** TITLE *****

SAMPLE PROBLEM NUMBER TWO

***** UNITS *****

LENGTH	FORCE
FEET	KIPS

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

DATUM ELEVATION = 1000.00
DIFFERENCE IN ELEVATION = 0.00

AYER UMBER	SOIL TYPE	INTERFACE ELEVATION	DATUM ELEVATIONS	THICKNESS	UNIT WEIGHT
		125.00	1000.00		
1	SAND			10.00	.1200
		115.00	990.00		
2	CLAY			15.00	.1200
		100.00	975.00		
3	CLAY			6.50	.1274
		93.50	968.50		
4	SAND			25.00	.1324
		68.50	943.50		
5	CLAY			20.50	.1324
		48.00	923.00		

UNIT WEIGHT OF WATER	GROUND WATER LEVEL	GROUND WATER DATUM ELEVATION
.0624	100.00	975.00

```
**********************
NSITU EFFECTIVE STRESS *
**********************
```

LAYER NUMBER	INPUT VALUE	CALCULATED VALUE	INSITU STRESS
1	-	.6000	.6000
2	-	2.1000	2.1000
3	-	3.2112	3.2112
4	-	4.2[illegible]	[illegible]

FIGURE 20b

OUTPUT

SAMPLE PROBLEM 2

EFFECTIVE STRESS INCREMENTS INPUT BY A DISTRIBUTION FUNCTION

***** STRESS INCREMENTS FOR STRATUM *****

POINT NUMBER	STRESS INCREMENT
1	.7000
2	.7500
3	.7500

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

LAYER NUMBER	VALUE
2	.6400
3	.3300
5	.0600

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

LAYER NO.	PT. NO.	STRESS INCREMENT	STRESS VALUES
2	1	.4480	2.5480
2	2	.4800	3.0280
2	3	.4800	3.5080
3	1	.2310	3.4422
3	2	.2475	3.6897
3	3	.2475	3.9372
5	1	.0420	5.9320
5	2	.0450	5.9770
5	3	.0450	6.0220

DEFORMATION CURVES INPUT BY REFERENCE POINTS AND SLOPES

***** REFERENCE POINTS *****

LAYER NUMBER	POINT NUMBER	STRAIN	EFFECTIVE STRESS
2	2	.0026	5.4000
3	2	0.0000	3.2113
5	2	.0015	7.2000

***** EFFECTIVE STRESS VALUES AT POINTS ON THE DEFORMATION CURVES *****

LAYER NUMBER	POINT NUMBER	EFFECTIVE STRESS
2	1	.1000
2	2	5.4000
2	3	10.0000
3	1	.1000
3	2	3.2113
3	3	10.0000
5	1	.1000

Figure 20b
OUTPUT
SAMPLE PROBLEM

***** SLOPES OF THE DEFORMATION CURVES *****

LAYER NUMBER	LINE NUMBER	CC (STRAIN)	CE (STRAIN)
2	1	.0063	.0063
2	2	.0625	.0063
3	1	.0131	.0131
3	2	.1333	.0133
5	1	.0171	.0171
5	2	.1765	.0176

****
SAND SETTLEMENT DATA *
****

***** FOUNDATION DATA *****

FOOTING WIDTH	FOOTING PRESSURE	FOOTING ELEVATION
20.0000	4.5000	115.0000

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

MEYERHOF

***** PENETRATION RESISTANCE *****

LAYER NUMBER	SPT BLOWCOUNT	STATIC CONE PENETRATION RESISTANCE
1	20.00	-
4	45.00	-

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

ONE LENGTH UNIT EQUALS	1.0000	FEET
ONE FORCE UNIT EQUALS	.5000	TONS

***** STRAIN INFLUENCE FUNCTION *****

THE STRAIN INFLUENCE FUNCTION USED IS CURVE G

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

***** SETTLEMENT BY LAYERS *****

LAYER NUMBER	STRESS INTERVAL	INCREMENTAL SETTLEMENT
2	1 TO 2	.00787
2	2 TO 3	.00702
2	3 TO 4	.00599
2	LAYER HISTORY	.02088

Figure 20b

OUTPUT

SAMPLE PROBLE

5	1 TO 2	.00108
5	2 TO 3	.00115
5	3 TO 4	.00114
5	LAYER HISTORY	.00337

***** SETTLEMENT BY STRESS INTERVAL *****

STRESS INTERVAL	SETTLEMENT OVER PROFILE
1 TO 2	.03509
2 TO 3	.03420
3 TO 4	.03136
TOTAL CLAY SETTLEMENT	.10065

****
CLAY COMPRESSIBILITIES *
****

AYER	STRESS	MV	DELTA E	E1	E2
2	1 TO 2	.00117	.00052	-.00000	.000
2	2 TO 3	.00098	.00047	.00052	.000
2	3 TO 4	.00083	.00040	.00099	.001
3	1 TO 2	.01741	.00402	-.00000	.004
3	2 TO 3	.01624	.00402	.00402	.008
3	3 TO 4	.01519	.00376	.00804	.0
5	1 TO 2	.00126	.00005	.00001	.000
5	2 TO 3	.00125	.00006	.00006	.000
5	3 TO 4	.00124	.00006	.00012	.000

****
SAND SETTLEMENTS *
****

***** SETTLEMENT IN SAND LAYERS *****

THE STRAIN WEIGHTED AVERAGE BLOWCOUNT = 45.0000

LAYER NUMBER	MEYERHOF
1	0.0000
4	.0060
TOTAL SAND SETTLEMENT	.0060
TOTAL CLAY SETTLEMENT	.1006

Figure 20:
OUTPUT
SAMPLE PROBL...

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

```
*************************
* SPECIFICATIONS FOR *
*   PROBLEM NO. 3    *
*************************
```

***** TITLE *****

SAMPLE PROBLEM NUMBER THREE

***** UNITS *****

LENGTH	FORCE
FEET	KIPS

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

LAYER NUMBER	SOIL TYPE	INTERFACE ELEVATION	DATUM ELEVATIONS	THICKNESS	UNIT WEIGHT
		100.00	-		
1	SAND			3.00	.1150
		97.00	-		
[illegible]	SAND			3.00	.1150
		94.00	-		
3	SAND			44.00	.1154
		50.00	-		

UNIT WEIGHT OF WATER	GROUND WATER LEVEL	GROUND WATER DATUM ELEVATION
.0624	94.00	-

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

LAYER NUMBER	INPUT VALUE	CALCULATED VALUE	INSITU STRESS
1	-	.1725	.1725
2	-	.5175	.5175
3	-	1.8560	1.8560

FIGURE 20c

OUTPUT

SAMPLE PROBLEM 3

```
*******************
* SETTLEMENT DATA *
*******************
```

***** FOUNDATION DATA *****

FOOTING WIDTH   FOOTING   FOOTING

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

MEYERHOF
DAPPOLONIA
SCHMERTMANN

***** PENETRATION RESISTANCE *****

LAYER NUMBER	SPT BLOWCOUNT	STATIC CONE PENETRATION RESISTANCE
1	10.00	80.0000
2	12.00	95.0000
3	15.00	120.0000

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

ONE LENGTH UNIT EQUALS	1.0000	FEET
ONE FORCE UNIT EQUALS	.5000	TONS

***** DAPPOLONIA*S PARAMETERS *****

EMBEDMENT CORRECTION U0	=	.9700
LAYER THICKNESS CORRECTION U1	=	1.6500
MODULUS INTERCEPT	=	533.0000
MODULUS SLOPE	=	22.2000

***** STRAIN INFLUENCE FUNCTION *****

THE STRAIN INFLUENCE FUNCTION USED IS CURVE G

THERE ARE NO CLAY LAYERS IN THE SOIL PROFILE

****
SAND SETTLEMENTS *
****

***** SETTLEMENT IN SAND LAYERS *****

THE STRAIN WEIGHTED AVERAGE BLOWCOUNT = 14.2866

DAPPOLONIA COMPRESSIBILITY MODULUS = 850.1624

LAYER	MEYERHOF	DAPPOLONIA	SCHMERTMANN
1	0.0000	0.0000	0.0000
2	.0127	.0134	.0250
3	.0408	.0430	.0641
TOTAL SAND SETTLEMENT	.0535	.0565	.0890

Figure
OUTPU
SAMPLE PR

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

```
***********************
* SPECIFICATIONS FOR  *
*   PROBLEM NO.  4    *
***********************
```

***** TITLE *****
SAMPLE PROBLEM NUMBER FOUR

***** UNITS *****

LENGTH	FORCE
FEET	KIPS

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

LAYER NUMBER	SOIL TYPE	INTERFACE ELEVATION	DATUM ELEVATIONS	THICKNESS	UNIT WEIGHT
		100.00	-		
1	SAND			3.00	.1150
		97.00	-		
2	SAND			3.00	.1150
		94.00	-		
3	SAND			44.00	.1154
		50.00	-		

UNIT WEIGHT OF WATER	GROUND WATER LEVEL	GROUND WATER DATUM ELEVATION
.0624	94.00	-

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

LAYER NUMBER	INPUT VALUE	CALCULATED VALUE	INSITU STRESS
1	.1000	.1725	.2725
2	.0500	.5175	.5675
3	.0250	1.8560	1.8810

FIGURE 20d
OUTPUT
SAMPLE PROBLEM 4

```
*  *****************
 SAND SETTLEMENT DATA *
************************
```

***** FOUNDATION DATA *****

FOOTING   FOOTING   FOOTING

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

MEYERHOF
DAPPOLONIA
SCHMERTMANN

***** PENETRATION RESISTANCE *****

LAYER NUMBER	SPT BLOWCOUNT	STATIC CONE PENETRATION RESISTANCE
1	10.00	80.0000
2	12.00	95.0000
3	15.00	120.0000

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

ONE LENGTH UNIT EQUALS 1.0000 FEET
ONE FORCE UNIT EQUALS .5000 TONS

***** DAPPOLONIA*S PARAMETERS *****

EMBEDMENT CORRECTION U0 = .9700
LAYER THICKNESS CORRECTION U1 = 1.6500
MODULUS INTERCEPT = 533.0000
MODULUS SLOPE = 22.2000

***** STRAIN INFLUENCE FUNCTION *****

THE STRAIN INFLUENCE FUNCTION USED IS CURVE F

THERE ARE NO CLAY LAYERS IN THE SOIL PROFILE

****
ND SETTLEMENTS *
****

***** SETTLEMENT IN SAND LAYERS *****

THE STRAIN WEIGHTED AVERAGE BLOWCOUNT = 14.7300

DAPPOLONIA COMPRESSIBILITY MODULUS = 860.0060

LAYER	MEYERHOF	DAPPOLONIA	SCHMERTMANN
1	0.0000	0.0000	0.0000
2	.0047	.0050	.0070
3	.0472	.0508	.0565
TOTAL SAND SETTLEMENT	.0519	.0558	.0635

Figure 2C
OUTPUT
SAMPLE PROB

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

```
*******************
ECIFICATIONS FOR *
PROBLEM NO. 5    *
*******************
```

***** TITLE *****

SAMPLE PROBLEM NUMBER FIVE

***** UNITS *****

LENGTH	FORCE
CENTIMETERS	KILOGRAMS

```
*************
OIL PROFILE *
SCRIPTION   *
*************
```

R ER	SOIL TYPE	INTERFACE DEPTH	DATUM ELEVATIONS	THICKNESS	UNIT WEIGHT
		0.00	-		
1	INCOMP			200.00	.0016
		200.00	-		
2	SAND			100.00	.0020
		300.00	-		
3	SAND			30.00	.0020
		330.00	-		
	SAND			170.00	.0020
		500.00	-		
	SAND			50.00	.0020
		550.00	-		
6	SAND			100.00	.0020
		650.00	-		
7	SAND			70.00	.0020
		720.00	-		
8	INCOMP			80.00	.0020
		800.00	-		

UNIT WEIGHT OF WATER	GROUND WATER LEVEL	GROUND WATER DATUM ELEVATION
.0010	1000.00	-

FIGURE 20e

OUTPUT

SAMPLE PROBLEM 5

```
***********************
NSITU EFFECTIVE STRESS *
 **********************
```

LAYER NUMBER	INPUT VALUE	CALCULATED VALUE	INSITU STRESS
1	-	.1600	.1600

6	-	1.1200	1.1200
7	-	1.2900	1.2900
8	-	1.4400	1.4400

****
AND SETTLEMENT DATA *
****

***** FOUNDATION DATA *****

FOOTING WIDTH	FOOTING PRESSURE	FOOTING DEPTH
260.0000	1.8200	200.0000

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

SCHMERTMANN

***** PENETRATION RESISTANCE *****

LAYER NUMBER	SPT BLOWCOUNT	STATIC CONE PENETRATION RESISTANCE
2	-	25.0000
3	-	35.0000
4	-	35.0000
5	-	70.0000
6	-	30.0000
7	-	85.0000

***** STRAIN INFLUENCE FUNCTION *****

THE STRAIN INFLUENCE FUNCTION USED IS CURVE F

THERE ARE NO CLAY LAYERS IN THE SOIL PROFILE

****
AND SETTLEMENTS *
****

***** SETTLEMENT IN SAND LAYERS *****

LAYER NUMBER	SCHMERTMANN
2	.6185
3	.3048
4	1.5270
5	.1436
6	.4123
7	.0297
TOTAL SAND SETTLEMENT	3.0359

Figure 20e
OUTPUT
SAMPLE PROBLEM

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

```
*******************
PECIFICATIONS FOR *
 PROBLEM NO. 6    *
*******************
```

***** TITLE *****

SAMPLE PROBLEM NUMBER SIX

```
*************
OIL PROFILE *
ESCRIPTION  *
*************
```

/ER /BER	SOIL TYPE	INTERFACE DEPTH	DATUM ELEVATIONS	THICKNESS	UNIT WEIGHT
		0.00	-		
	INCOMP			200.00	.0016
		200.00	-		
2	SAND			100.00	.0020
		300.00	-		
	SAND			30.00	.0020
		330.00	-		
	SAND			170.00	.0020
		500.00	-		
5	SAND			50.00	.0020
		550.00	-		
	SAND			100.00	.0020
		650.00	-		
7	SAND			70.00	.0020
		720.00	-		
[illegible]	INCOMP			80.00	.0020
		800.00	-		

UNIT WEIGHT OF WATER	GROUND WATER LEVEL	GROUND WATER DATUM ELEVATION
.0010	1000.00	-

```
*********************
ISITU EFFECTIVE STRESS *
*********************
```

LAYER NUMBER	INPUT VALUE	CALCULATED VALUE	INSITU STRESS
1	-	.1600	.1600
2	-	.4200	.4200
3	-	.5500	.5500
4	-	.7500	.7500
5	-	[illegible]	

FIGURE 20f

OUTPUT

SAMPLE PROBLEM 6

```
*********************
AND SETTLEMENT DATA *
*********************

              ***** FOUNDATION DATA *****
     FOOTING           FOOTING          FOOTING
      WIDTH            PRESSURE          DEPTH

     260.0000           1.8200          200.0000


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

                      DAPPOLONIA


        ***** PENETRATION RESISTANCE *****
    LAYER               SPT              STATIC CONE
    NUMBER           BLOWCOUNT       PENETRATION RESISTANCE

      2                6.75                  -
      3                8.75                  -
      4                8.75                  -
      5               17.50                  -
      6                7.50                  -
      7               21.25                  -


        ***** DAPPOLONIA*S PARAMETERS *****

 EMBEDMENT CORRECTION UO            =       .7500
 LAYER THICKNESS CORRECTION U1 =      2.2000
 MODULUS INTERCEPT                  =    250.0000
 MODULUS SLOPE                      =     10.0000


        ***** STRAIN INFLUENCE FUNCTION *****
       POINT           Z/B              IZ
                    COORDINATE       COORDINATE

         1            0.000             .200
         2             .375             .700
         3            2.000            0.000


      THERE ARE NO CLAY LAYERS IN THE SOIL PROFILE


****************
ND SETTLEMENTS *
****************

         ***** SETTLEMENT IN SAND LAYERS *****

    THE STRAIN WEIGHTED AVERAGE BLOWCOUNT =      9.0274

      DAPPOLONIA COMPRESSIBILITY MODULUS =   340.2736
```

Figure :

OUTP(

SAMPLE PRO:

3	.2409
4	1.0280
5	.1933
6	.2379
7	.0486
TOTAL SAND SETTLEMENT	2.2946

Figure 20f
OUTPUT
SAMPLE PROBLEM

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

```
*******************
PECIFICATIONS FOR *
 PROBLEM NO.  7   *
*******************
```

***** TITLE *****
SAMPLE PROBLEM NUMBER SEVEN

***** UNITS *****

LENGTH	FORCE
FEET	KIPS

```
************
OIL PROFILE *
ESCRIPTION  *
************
```

DATUM ELEVATION = 41.16
DIFFERENCE IN ELEVATION = -22.73

YER MBER	SOIL TYPE	INTERFACE DEPTH	DATUM ELEVATIONS	THICKNESS	UNIT WEIGHT
		0.00	18.43		
1	CLAY			4.50	-0.0000
		4.50	13.93		
2	CLAY			4.50	-0.0000
		9.00	9.43		
3	CLAY			4.50	-0.0000
		13.50	4.93		
4	CLAY			4.50	-0.0000
		18.00	.43		

UNIT WEIGHT OF WATER	GROUND WATER LEVEL	GROUND WATER DATUM ELEVATION
.0624	0.00	18.43

```
***********************
NSITU EFFECTIVE STRESS *
***********************
```

LAYER NUMBER	INPUT VALUE	CALCULATED VALUE	INSITU STRESS
1	4.6700	-	4.6700
2	5.0200	-	5.0200
3	5.3800	-	5.3800
4	5.7400	-	5.7400

FIGURE 20g
OUTPUT
SAMPLE PROBLEM 7

EFFECTIVE STRESS INCREMENTS INPUT BY LAYER

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

LAYER NO.	PT. NO.	STRESS INCREMENT	STRESS VALUES
1	1	-.3000	4.3700
1	2	.4000	4.7700
1	3	.4000	5.1700
1	4	.9000	6.0700
1	5	3.3000	9.3700
1	6	.8000	10.1700
1	7	.6000	10.7700
1	8	-.6000	10.1700
2	1	-.9000	4.1200
2	2	.4000	4.5200
2	3	.5000	5.0200
2	4	.8000	5.8200
2	5	3.2000	9.0200
2	6	.8000	9.8200
2	7	.6000	10.4200
2	8	-.1000	10.3200
3	1	-2.0000	3.3800
3	2	1.0000	4.3800
3	3	.5000	4.8800
3	4	.7000	5.5800
3	5	3.5000	9.0800
3	6	.6000	9.6800
3	7	.6000	10.2800
3	8	.2000	10.4800
4	1	-2.7000	3.0400
4	2	1.1000	4.1400
4	3	.2000	4.3400
4	4	.9000	5.2400
4	5	3.6000	8.8400
4	6	.5000	9.3400
4	7	.6000	9.9400
4	8	.8000	10.7400

DEFORMATION CURVES INPUT BY REFERENCE POINTS AND SLOPES

***** REFERENCE POINTS *****

LAYER NUMBER	POINT NUMBER	VOID RATIO	EFFECTIVE STRESS
1	1	.8100	2.0000
2	2	.8100	5.0000
3	2	.8100	5.0000
4	4	.5810	50.0000

Figure 20
OUTPUT
SAMPLE PROBL

***** EFFECTIVE STRESS VALUES AT POINTS ON THE DEFRMATION CURVES *****

LAYER NUMBER	POINT NUMBER	EFFECTIVE STRESS
1	1	2.0000
1	2	5.0000
1	3	8.7700

2	3	8.7700
2	4	50.0000
3	1	2.0000
3	2	5.0000
3	3	8.7700
3	4	50.0000
4	1	2.0000
4	2	5.0000
4	3	8.7700
4	4	50.0000

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

AYER UMBER	LINE NUMBER	CC	CE	CC (STRAIN)	CE (STRAIN)
1	1	0.0000	0.0000	0.0000	0.0000
1	2	.0400	.0400	.0221	.0221
1	3	.2900	.0400	.1611	.0222
2	1	0.0000	0.0000	0.0000	0.0000
2	2	.0400	.C400	.0221	.0221
2	3	.2900	.0400	.1611	.0222
3	1	0.0000	0.0000	0.0000	0.0000
3	2	.0400	.C400	.0221	.0221
3	3	.2900	.C400	.1611	.0222
4	1	0.0000	0.0000	0.0000	0.0000
4	2	.0400	.C400	.0221	.0221
4	3	.2900	.C400	.1611	.0222

****
LAY SETTLEMENT CONTRIBUTIONS *
****

***** SETTLEMENT BY LAYERS *****

LAYER NUMBER	STRESS INTERVAL	INCREMENTAL SETTLEMENT
1	1 TO 2	0.00000
1	2 TO 3	0.00000
1	3 TO 4	.00144
1	4 TO 5	.00593
1	5 TO 6	.03661
1	6 TO 7	.02565
1	7 TO 8	.01795
1	8 TO 9	-.00248
1	LAYER HISTORY	.08612
2	1 TO 2	-.00017
2	2 TO 3	0.00000
2	3 TO 4	.00017
2	4 TO 5	.00639
2	5 TO 6	.02651
2	6 TO 7	.02661
2	7 TO 8	.01357
2	8 TO 9	-.00042
2	LAYER HISTORY	.07765

Figure 20g
OUTPUT
SAMPLE PROBLEM

3	4		5	.00474
3	5	)	6	.03043
3	6	TO	7	.02005
3	7	TO	8	.01384
3	8	TO	9	.00604
3	LAYER HISTORY			.07694
4	1	TO	2	-.00597
4	2	TO	3	0.00000
4	3	TO	4	0.00000
4	4	TO	5	.00203
4	5	TO	6	.02477
4	6	TO	7	.01725
4	7	TO	8	.01952
4	8	TO	9	.02427
4	LAYER HISTORY			.08187

***** SETTLEMENT BY STRESS INTERVAL *****

STRESS INTERVAL			SETTLEMENT OVER PROFILE
1	TO	2	-.00931
2	TO	3	0.00000
3	TO	4	.00162
4	TO	5	.02009
5	TO	6	.11832
6	TO	7	.08956
7	TO	8	.07489
8	TO	9	.02742

TOTAL CLAY SETTLEMENT .32258

Figure 20g
OUTPUT
SAMPLE PROBLEM 7

****
CLAY COMPRESSIBILITIES *
****

YER	STRESS			MV	DELTA E	E1	E2
	1	TO	2	0.00000	0.00000	.81000	.81000
	2	TO	3	0.00000	0.00000	.81000	.81000
	3	TO	4	.00080	.00058	.81000	.80942
	4	TO	5	.00171	.00279	.80942	.80663
	5	TO	6	.00247	.01473	.80663	.79190
	6	TO	7	.00720	.01032	.79190	.78159
	7	TO	8	.00675	.00722	.78159	.77437
	8	TO	9	.00094	-.00100	.77437	.77536
	1	TO	2	.00004	-.00007	.80993	.81000
	2	TO	3	0.00000	0.00000	.81000	.81000
	3	TO	4	.00008	.00007	.81000	.80993
	4	TO	5	.00177	.00257	.80993	.80736
	5	TO	6	.00184	.01066	.80736	.79670
	6	TO	7	.00745	.01070	.79670	.78600
	7	TO	8	.00697	.00747	.78600	.77853
	8	TO	9	.00094	-.00017	.77853	.77869
	1	TO	2	.00035	-.00127	.80873	.81000
	2	TO	3	0.00000	0.00000	.81000	

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.7878
3	7	TO	8	.00706	.00757	.78780	.7802
3	8	TO	9	.00682	.00243	.78023	.7778
4	1	TO	2	.00049	-.00240	.80759	.8099
4	2	TO	3	0.00000	0.00000	.80999	.809
4	3	TO	4	0.00000	0.00000	.80999	.809
4	4	TO	5	.00050	.00081	.80999	.8091
4	5	TO	6	.00153	.00995	.80918	.7992
4	6	TO	7	.00770	.00693	.79923	.7923
4	7	TO	8	.00729	.00784	.79230	.7844
4	8	TO	9	.00683	.00975	.78446	.7747

THERE ARE NO SAND LAYERS IN THE SOIL PROFILE

Figure 20g

OUTPUT

SAMPLE PROBLEM 7

Chapter 5 - PROGRAM STATISTICS

MAGSET-II, Version 1, was developed to run on any computer which has an ANSI FORTRAN IV compiler. The program consists of a main routine and twenty-seven subroutines. The subroutine calling sequence is shown in Figure 21. The functions of the main routine and the subroutines are detailed in the reference documentation (Partyka, 1976).

The field length requirements for loading and executing the compiled program are shown in Table 5.1.

TABLE 5.1

FIELD LENGTH REQUIREMENTS TO LOAD AND EXECUTE

Compiler	Field Length
RUN	$35,100_8$ words
FTN	$45,600_8$ words
MNF	$33,700_8$ words
FORTRAN IV G (IBM)	132,000 bytes

The sample problems were run at the University of Colorado Computing Center, using the KRONOS 2.1 operating system on a CDC 6400 computer. The load and execution time data for the compiled programs are given in Table 5.2.

TABLE 5.2

LOAD AND EXECUTION TIME IN SECONDS

SAMPLE PROBLEMS

Compiler	Time
RUN	4.03
FTN	3.72
MNF	3.61

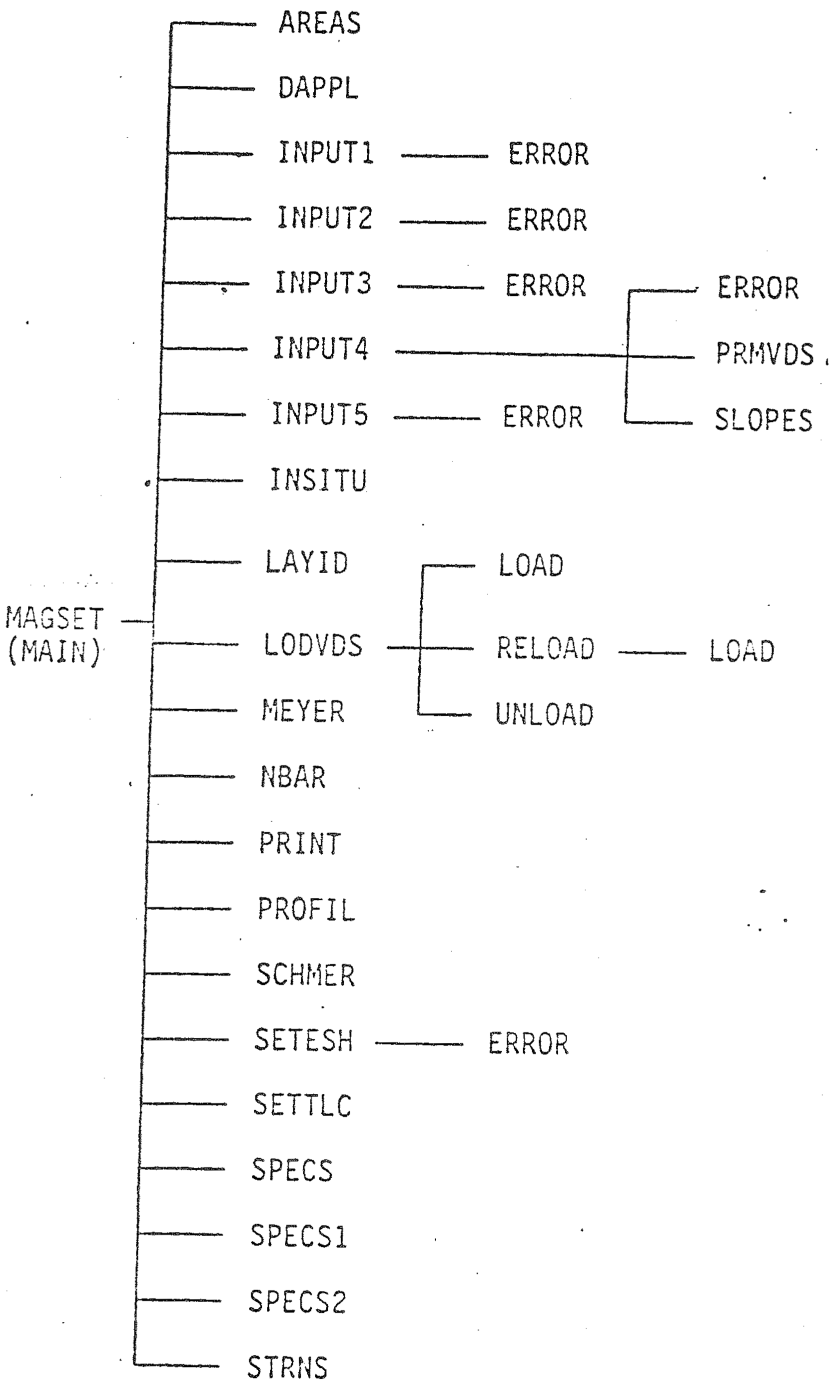

FIGURE 21

SUBROUTINE CALLING SEQUENCE