APPENDIX F
COMPUTER PROGRAM VDISPL

F-1. Background. This program, Vertical DISPLacements, was developed to assist in the calculation of vertical displacements beneath shallow foundations for various types of multilayered soils in support of this manual. The two types of foundations considered are rectangular footings or mats and long strip footings. These foundations are assumed flexible. Models available are immediate settlement of granular soil from cone penetration data (item 55), immediate settlement of granular soil from both cone penetration and dilatometer data (item 37), immediate settlement of an elastic soil using the Boussinesq pressure distribution and Young’s elastic soil modulus, consolidation or swell of a cohesive soil (ASTM D 4546), and settlement of a collapsible soil (item 22). Soil expansion is indicated by positive values and settlement by negative values.

F-2. Organization. The program consists of a main routine and several subroutines for calculation of vertical displacements by each of the models. The main routine feeds in descriptive data for the problem, divides the soil profile into increments from 1 to NNP where NNP is the nodal point at the bottom of the profile, assigns a layer number to each increment or soil element, and calculates the effective overburden pressure prior to placement of the foundation. The number of soil elements NEL in a problem is one less than the number of nodal points NNP. The PARAMETER statement in the program provides a maximum NL=30 soil layers and a maximum NQ=101 soil nodal points. Subroutine SLAB calculates the change in effective vertical pressures in the soil following placement of the foundation using the Boussinesq pressure distribution. The remaining subroutines described below calculate vertical displacements for the various models.

a. Data Organization. The input data are placed in a file, "VDIN.DAT". These data are illustrated in Table F-1 with descriptions provided in Table F-2. The input data are also printed in the output file, "VDOU.DAT" and illustrated in Table F-3. Calculations by the program are printed in VDOU.DAT and illustrated in Table F-3.

b. Subroutine MECH. This subroutine (NOPT=0) calculates heave or consolidation from results of one-dimensional consolidometer swell tests performed on cohesive soil for each layer in a soil profile.

(1) Soil displacements are calculated after ASTM standard D 4546 (method C) relative to the equilibrium moisture profiles of saturated (method 1), hydrostatic with shallow water table (method 2), and hydrostatic without shallow water table (method 3), Figure 5-1.

(2) Input data includes swell pressure, swell and compression indices, and the maximum past pressure of each soil layer. Incremental and total settlement in soil adjacent to the foundation and below the foundation may be calculated.

c. Subroutine LEON. This subroutine (NOPT=1) calculates immediate settlement of shallow foundations on granular soils using both cone penetration and dilatometer in situ test data. This method considers effects of prestress after the model of Leonards and Frost (item 37)

Table F-1

Input Data

Line	Input Parameters	Format Statement
1	TITLE	20A4
2	MPROB NOPT NBPRES NNP NBX NMAT DX	6I5,F10.2
3	N IE(N,M) (Line 3 repeated for each new material, M=1,NMAT; last line is NEL NMAT)	2I5
4	M G(M) WC(M) EO(M) (Line 4 repeated for each new material, M=1,NMAT)	I5,3F10.3
5	DGWT IOPTION NOUT	F10.2,2I5
6	Q BLEN BWID MRECT	3F10.2,I5
7	If NOPT=0 M SP(M) CS(M) CC(M) PM(M)	I5,4F10.4
	If NOPT=1 M PO(M) P1(M) QC(M)	I5,3F10.2
	If NOPT=2 M QC(M)	I5,F10.2
	If NOPT=3 M PRES(M,J),J=1,5	I5,5F10.2
	If NOPT=4 M ES(M)	I5,F10.2
	(Line 7 repeated for each new material, M=1,NMAT)	
8	If NOPT=0 XA XF	2F10.2
	If NOPT=2 or 4 TIME	F10.2
	If NOPT=3 M STRA(M,J),J=1,5 (This line repeated for each new material, M=1,NMAT)	I5,5F10.2

Table F-2

Description of Input Data

Line	Parameter	Description
1	TITLE	Name of problem
2	NPROB	Number of problems; If NPROB >1, then the program repeats calculations with new input data beginning with Line 5
	NOPT	Option for model: =0 for consolidation/swell =1 for Leonards and Frost =2 for Schmertmann =3 for Collapsible soil =4 for elastic soil settlement
	NBPRES	Option for foundation: =1 for rectangular slab =2 for long strip footing
	NNP	Total number of nodal points; vertical displacements calculated to depth DX*(NNP-1)
	NBX	Number of nodal point at bottom of foundation
	NMAT	Total number of different soil layers
	DX	Increment of depth, ft
3	N	Element number
	IE(N,M)	Number of soil layer M associated with element N
4	M	Number of soil layer
	G(M)	Specific gravity of soil layer M
	WC(M)	Water content of soil layer M, percent
	EO(M)	Initial void ratio of soil layer M
5	DGWT	Depth to hydrostatic water table, ft; If NOPT=0 and IOPTION =1, then set DGWT=ZA+Uwa/0.03125 where Uwa= suction (or positive value of negative pore water pressure),tsf at depth ZA (method 3, Figure 5-1); If Uwa=0, then DGWT=ZA (method 2, Figure 5-1); set NNP= 1+ ZA/DX to prevent displacement calculations below depth ZA
	IOPTION	Equilibrium moisture profile: =0 for saturation above the water table (method 1, Figure 5-1); if NOPT=0, then =1 for hydrostatic above water table
	NOUT	Amount of output data, =0 only total displacements =1 for increments with totals
6	Q	Applied uniform pressure on foundation, tsf
	BLEN	Length of foundation or 0.0 if NBPRES=2, ft
	BWID	Width of foundation or long continuous footing, ft
	MRECT	Location of calculation: =0 for center and =1 for corner of rectangle or edge of long footing

Table F-2. Concluded

Line	Parameter	Description
7		If NOPT=0
	M	Number of soil layer
	SP(M)	Swell pressure of soil layer M, tsf
	CS(M)	Swell index of soil layer M
	CC(M)	Compression index of soil layer M
	PM(M)	Maximum past pressure of soil layer M, tsf
		If NOPT=1
	M	Number of soil layer
	PO(M)	Dilatometer A-pressure, tsf
	P1(M)	Dilatometer B-pressure, tsf
	QC(M)	Cone penetration resistance, tsf
		If NOPT=2
	M	Number of soil layer
	QC(M)	Cone penetration resistance, tsf
		If NOPT=3
	M	Number of soil layer
	PRES(M,5)	Applied pressure at 5 points of collapsible soil test, tsf; must be greater than zero
		If NOPT=4
	M	Number of soil layer
	ES(M)	Elastic modulus, tsf
8		If NOPT=0
	ZA	Depth of active zone of heave, ft
	XF	Depth from ground surface to the depth that heave begins, ft
		If NOPT=2 or 4
	TIME	Time in years after construction for Schmertmann model
		If NOPT=3
	M	Number of soil layer
	STRA(M,5)	Strain at 5 points of collapsible soil test, percent

Table F-3

Output Data

Line	Output Parameters	Fortran Statement
1	TITLE	20A4
2	NUMBER OF PROBLEMS=	I5
	NUMBER OF NODAL POINTS=	I5
3	NUMBER OF NODAL POINT AT BOTTOM OF FOUNDATION=	I11
4	NUMBER OF DIFFERENT SOIL LAYERS=	I5
	INCREMENT DEPTH=	F10.2
5	If NOPT=0 CONSOLIDATION SWELL MODEL	
	If NOPT=1 LEONARDS AND FROST MODEL	
	If NOPT=2 SCHMERTMANN MODEL	
	If NOPT=3 COLLAPSIBLE SOIL	
	If NOPT=4 ELASTIC SOIL	
6	If NBPRES=1 RECTANGULAR SLAB FOUNDATION	
	If NBPRES=2 LONG CONTINUOUS STRIP FOUNDATION	
7	DEPTH OF FOUNDATION= FEET	F10.2
8	TOTAL DEPTH OF SOIL PROFILE= FEET	F10.2
9	ELEMENT NUMBER OF SOIL	I5,8X,I5
10	MATERIAL SPECIFIC GRAVITY WATER CONTENT, % VOID RATIO	I5,3F10.3
11	DEPTH TO WATER TABLE= FEET	F10.2
12	If NOUT=0 TOTAL DISPLACEMENTS ONLY	

Table F-3. Continued

Line	Output Parameters	Fortran Statement
	If NOUT=1 DISPLACEMENTS AT EACH DEPTH OUTPUT	
13	If IOPTION=0 or NOPT=0 EQUILIBRIUM SATURATED ABOVE WATER TABLE	
	If IOPTION=1 and NOPT=0 EQUILIBRIUM HYDROSTRATIC PROFILE ABOVE WATER TABLE	
14	APPLIED PRESSURE ON FOUNDATION= TSF	F10.2
15	LENGTH= FEET WIDTH= FEET	F10.2,F10.2
15	If MRECT=0 CENTER OF FOUNDATION	
	If MRECT=1 CORNER OF SLAB OR EDGE OF LONG STRIP FOOTING	
If NOPT=0		
17	MATERIAL SWELL PRESSURE, TSF SWELL INDEX COMPRESSION INDEX MAXIMUM PAST PRESSURE,TSF	I5,4F15.3
18	ACTIVE ZONE DEPTH (FT)=	F10.2
	DEPTH ACTIVE ZONE BEGINS (FT)=	F10.2
	If NOUT=1	
19A	HEAVE DISTRIBUTION ABOVE FOUNDATION DEPTH ELEMENT DEPTH,FT DELTA HEAVE,FT EXCESS PORE PRESSURE,TSF	I5,F13.2,2F18.5
19B	HEAVE DISTRIBUTION BELOW FOUNDATION DEPTH ELEMENT DEPTH,FT DELTA HEAVE,FT EXCESS PORE PRESSURE,TSF	
20	SOIL HEAVE NEXT TO FOUNDATION EXCLUDING HEAVE IN SUBSOIL BENETH FOUNDATION= FEET	F8.5
	SUBSOIL MOVEMENT= FEET	F8.5
	TOTAL HEAVE FEET	F8.5
If NOPT=1		
17	MATERIAL A PRESSURE, TSF B PRESSURE, TSF CONE RESISTANCE, TSF	I5,3F18.2
18	If NOUT=1 ELEMENT DEPTH, FT SETTLEMENT, FT KO QC/SIGV PHI,DEGREES	I5,F10.2,F13.5,3F10.2

Table F-3. Continued

Line	Output Parameters	Fortran Statement
19	SETTLEMENT BENEATH FOUNDATION= FEET	F10.5
If NOPT=2		
17	MATERIAL CONE RESISTANCE, TSF	I5,F18.2
18	TIME AFTER CONSTRUCTION IN YEARS=	F10.2
19	If NOUT=1 ELEMENT DEPTH, FT SETTLEMENT, FT	I5,F13.2,F18.5
20	SETTLEMENT BENEATH FOUNDATION= FEET	F10.5
If NOPT=3		
17	APPLIED PRESSURE AT 5 POINTS IN UNITS OF TSF MATERIAL A BB B C D	I5,5F10.2
18	STRAIN AT 5 POINTS IN PERCENT MATERIAL A BB B C D	I5,5F10.2
19	If NOUT=1 COLLAPSE DISTRIBUTION ABOVE FOUNDATION DEPTH ELEMENT DEPTH,FT DELTA,FT	I5,F13.2,F18.2
	COLLAPSE DISTRIBUTION BELOW FOUNDATION DEPTH ELEMENT DEPTH,FT DELTA,FT	I5,F13.2,F18.2
20	SOIL COLLAPSE NEXT TO FOUNDATION EXCLUDING COLLAPSE IN SUBSOIL BENEATH FOUNDATION FEET SUBSOIL COLLAPSE= FEET TOTAL COLLAPSE= FEET	 F10.5 F10.5 F10.5
If NOPT=4		
17	MATERIAL ELASTIC MODULUS, TSF	I5,F18.2
18	TIME AFTER CONSTRUCTION IN YEARS=	
	If NOUT=1	
19	SETTLEMENT DISTRIBUTION BELOW FOUNDATION ELEMENT DEPTH,FT DELTA,FT	I5,F13.2,F18.5
20	SUBSOIL SETTLEMENT BENEATH FOUNDATION FEET	F10.5

$$\rho_i = C_i \bullet \Delta p \bullet \Delta z \bullet \sum_{i=1}^{i=NEL} I_{iz} \left[\frac{R_{izoc}}{E_{izoc}} + \frac{R_{iznc}}{E_{iznc}} \right] \tag{F-1}$$

where

ρ_i = immediate settlement, ft
c_1 = correction to account for strain relief from embedment, $1 - 0.5\sigma'_o/\Delta p \geq 0.5$
σ'_o = effective vertical overburden pressure at bottom of footing, tsf
Δp = net applied footing pressure, $q - \sigma'_o$, tsf
q = bearing pressure on footing, tsf
Δz = depth increment, ft
I_{iz} = influence factor of soil layer i from Figure 3-4
R_{izoc} = ratio of stress increment corresponding to the overconsolidated part in soil layer i to the total stress increment in that layer
R_{iznc} = ratio of stress increment corresponding to the normally consolidated part in soil layer i to the total stress increment in that layer
E_{izoc} = Young's soil modulus of overconsolidated soil layer i at depth z, tsf
E_{iznc} = Young's soil modulus of normally consolidated soil layer i at depth z, tsf

(1) The ratios R_{iz} may be found as follows:

$$R_{izoc} = \frac{\sigma'_p - \sigma'_v}{\sigma'_f - \sigma'_v} \tag{F-2a}$$

$$R_{iznc} = \frac{\sigma'_f - \sigma'_p}{\sigma'_f - \sigma'_v} \tag{F-2b}$$

where

σ'_p = preconsolidation or maximum past pressure, tsf
σ'_v = initial vertical effective stress, tsf
σ'_f = final effective stress at the center of the layer, tsf

σ'_p is determined from σ'_v and the overconsolidation ratio, OCR.

(2) The OCR is estimated from (item 57)

$$OCR = \left[\frac{K_{oc}}{1 - \sin\phi_{ax}} \right]^{\frac{1}{0.8 \bullet \sin\phi_{ax}}} \tag{F-3}$$

where ϕ_{ax} is the axial friction angle, degrees. Equation F-3 was confirmed (item 37) for OCR between 2 and 20.

(3) ϕ_{ax} is estimated from the plane strain angle ϕ_{ps} by (item 57)

$$\phi_{ax} = \phi_{ps} - \left[\frac{\phi_{ps} - 32}{3} \right] \tag{F-4}$$

(4) The plane strain angle ϕ_{ps} is estimated from the coefficient of earth pressure and q_c/σ'_v using correlations suggested by (item 41). q_c is the cone penetration resistance, tsf. These correlations have been programmed in subroutine SPLINE. Subroutine BICUBIC is used to evaluate ϕ_{ps}. The coefficient of earth pressure is estimated using

$$K_{oc} = 0.376 + 0.095K_p - 0.0017(q_c/\sigma'_v) \tag{F-5}$$

where

K_{oc} = coefficient of earth pressure for overconsolidated soil
K_D = horizontal stress index, $(P_o - u_w)/\sigma'_v$
P_o = dilatometer lift-off pressure, tsf
u_w = in-situ pore water pressure, tsf

Settlements calculations are sensitive to the value of K_D, the horizontal stress index. If K_{oc} calculated by Equation F-5 exceeds 1.8, then the OCR calculated by Equation E-3 may exceed 20. The dilatometer lift-off pressure P_o should be a reliable value. Program VDISPL does not limit the value of K_{oc}. The constants in Equation F-5 may also differ from those for local soils.

(5) The elastic soil moduli are estimated by

$$E_{izoc} = 3.5E_p \tag{F-6a}$$

$$E_{iznc} = 0.7E_p \tag{F-6b}$$

where E_D = dilatometer modulus, tsf. E_D is given by

$$E_D = 34.7(P_1 - P_o) \tag{F-7}$$

where P_1 is the dilatometer B-pressure, the pressure required to expand the membrane 1.1 mm at the test depths. If $R_{izoc} = 0$, then $E_{iznc} = 0.9E_D$. Input data include the dilatometer A and B pressures and the cone resistance for each soil layer. Incremental and total settlement beneath the foundation may be calculated.

d. <u>Subroutine SCHMERT</u>. This subroutine (NOPT=2) calculates immediate settlement of shallow foundations on granular soils from cone penetration test data by the Schmertmann model (item 55)

$$\rho_i = C_i \bullet C_t \bullet \Delta p \bullet \Delta z \bullet \sum_{i=1}^{NEL} \frac{I_{iz}}{E_{si}} \tag{F-8}$$

where the input parameters are the same as above except E_{si} is the elastic soil modulus of layer i. $E_{si} = 2.5q_c$ for rectangular footings or mats and $E_{si} = 3.5q_c$ for long strip footings. C_t is a correction for time dependent increase in settlement

$$C_t = 1 + 0.2 \bullet \log_{10}(t/0.1) \tag{F-9}$$

(1) Input data include cone penetration resistance q_c for each soil layer and the time in years following construction when settlement is to be calculated. The incremental and total settlement beneath the foundation is calculated for the provided time.

(2) This subroutine includes an option (NOPT=4) to input E_{si} directly for each soil layer. This option may be useful if the user does not have cone penetration resistance data, but can determine reliable values of E_{si} by some other tests.

e. Subroutine COLL. This subroutine (NOPT=3) calculates the collapse settlement of susceptible soils after the model of Houston, et al (item 22). The model uses the results of a one-dimensional consolidometer test performed on collapsible soil for each soil layer, Figure 5-5. Input data include 5 points each of the applied pressure and strain distributions. The collapse settlement is calculated from the difference in strains between the unwetted line, points A-BB-B, and the wetted line, points A-C-D. Incremental and total settlement in soil adjacent and above the foundation and below the foundation may be calculated. The settlement caused by foundation loads prior to collapse may be estimated by the Leonards and Frost (NOPT=1, item 37) and Schmertmann (NOPT=2) models (item 57).

F-3. Example Problems

a. Heave of Expansive Soil. A footing 3 ft by 3 ft square, B = W = 3 ft, is to be constructed 3 ft below ground surface, D = 3 ft, on two cohesive expansive soil layers. The amount of heave is to be calculated if the soil is left untreated. The bottom of the soil profile is 8 ft below ground surface, which is also the depth to the ground water level. The depth increment DX is taken as 0.5 ft. The total number of nodal points NNP is selected as 17, number of elements NEL=NNP-1 or 16, and the nodal point at the bottom of the footing is NBX = (D/DX)+1 = 3/0.5 + 1 = 7. A schematic diagram of this problem is illustrated in Figure 5-6. The input parameters of data file VDIN.DAT for the consolidation/swell model, NOPT = 0, are given in Table F-4a. The maximum past pressures were omitted, which caused the program to assume these values equal with the swell pressures. The output data listed in data file VDOU.DAT shown in Table F-4b indicate substantial potential heave of 0.3 ft or 3.6 inches beneath the footing.

b. Settlement of Granular Soil. The same footing illustrated in Figure 5-6 is to be constructed in granular soil consisting of two distinctive layers. Field tests consisting of cone penetration and dilatometer data were obtained.

(1) The input parameters of data file VDIN.DAT for the Leonard and Frost model, NOPT = 1, are given in Table F-5a. The output data listed in data file VDOU.DAT shown in Table F-5b indicate 0.0092 ft or 0.11 inch of settlement beneath the footing.

(2) The same problem was applied to the Schmertmann model using the cone penetration resistance of the soil layers. The input data are given in Table F-6a. The output data shown in Table F-6b indicate 0.012 ft or 0.15 inch of settlement.

Table F-4

Expansive Soil Heave

a. Input data, file VDIN.DAT

```
       FOOTING IN EXPANSIVE SOIL
   1    0    1   17    7    2      0.50
   1    1
  12    2
  16    2
   1     2.700    20.000     1.540
   2     2.65     19.300     0.900
     8.00    0    1
     1.00      3.00      3.00    0
   1    2.0000    0.1500    0.2500
   2    3.0000    0.1000    0.2000
     8.00      0
```

b. Output Data, File VDOU.DAT

```
      FOOTING IN EXPANSIVE SOIL

NUMBER OF PROBLEMS=    1     NUMBER OF NODAL POINTS=   17
NUMBER OF NODAL POINT AT BOTTOM OF FOUNDATION=          7
NUMBER OF DIFFERENT SOIL LAYERS=    2     INCREMENT DEPTH=      0.50  FT

         CONSOLIDATION SWELL MODEL

         RECTANGULAR SLAB FOUNDATION

DEPTH OF FOUNDATION =                   3.00  FEET
TOTAL DEPTH OF THE SOIL PROFILE =       8.00  FEET
ELEMENT    NUMBER OF SOIL

   1            1
   2            1
   3            1
   4            1
   5            1
   6            1
   7            1
   8            1
   9            1
  10            1
  11            1
  12            2
  13            2
  14            2
  15            2
  16            2
```

Table F-4. Continued

MATERIAL	SPECIFIC GRAVITY	WATER CONTENT, %	VOID RATIO
1	2.700	20.000	1.540
2	2.650	19.300	0.900

DEPTH TO WATER TABLE = 8.00 FEET

DISPLACEMENTS AT EACH DEPTH OUTPUT

EQUILIBRIUM SATURATED PROFILE ABOVE WATER TABLE

APPLIED PRESSURE ON FOUNDATION= 1.00 TSF
LENGTH = 3.00 FEET WIDTH = 3.00 FEET

CENTER OF FOUNDATION

MATERIAL	SWELL PRESSURE, TSF	SWELL INDEX	COMPRESSION INDEX	MAXIMUM PAST PRESSURE,TSF

SWELL PRESSURE 2.00 WAS SET GREATER THAN MAXIMUM PAST PRESSURE 0.00

WHICH IS NOT POSSIBLE; SWELL PRESSURE SET EQUAL TO MAXIMUM PAST PRESSURE

1	2.000	0.150	0.250	2.000

SWELL PRESSURE 3.00 WAS SET GREATER THAN MAXIMUM PAST PRESSURE 0.00

WHICH IS NOT POSSIBLE; SWELL PRESSURE SET EQUAL TO MAXIMUM PAST PRESSURE

2	3.000	0.100	0.200	3.000

ACTIVE ZONE DEPTH (FT) = 8.00
DEPTH ACTIVE ZONE BEGINS (FT) = 0.00

HEAVE DISTRIBUTION ABOVE FOUNDATION DEPTH

ELEMENT	DEPTH,FT	DELTA HEAVE,FT	EXCESS PORE PRESSURE,TSF
1	0.25	0.13598	1.99003
2	0.75	0.10780	1.97010
3	1.25	0.09470	1.95017
4	1.75	0.08607	1.93024
5	2.25	0.07962	1.91031
6	2.75	0.03312	1.45017

HEAVE DISTRIBUTION BELOW FOUNDATION

ELEMENT	DEPTH,FT	DELTA HEAVE,FT	EXCESS PORE PRESSURE,TSF
7	3.25	0.01780	1.00071

Table F-4. Continued

8	3.75	0.01886	1.04123
9	4.25	0.02171	1.14230
10	4.75	0.02552	1.26050
11	5.25	0.02926	1.36090
12	5.75	0.03802	2.43160
13	6.25	0.03987	2.47576
14	6.75	0.04105	2.50203
15	7.25	0.04167	2.51531
16	7.75	0.04185	2.51923

```
SOIL HEAVE NEXT TO FOUNDATION EXCLUDING HEAVE
IN SUBSOIL BENEATH FOUNDATION = 0.26864  FEET

             SUBSOIL MOVEMENT = 0.15780  FEET
                  TOTAL HEAVE = 0.42645  FEET
```

Table F-5

Settlement of Granular Soil, Leonard and Frost Model

a. Input data, file VDIN.DAT

```
       FOOTING IN GRANULAR SOIL - LEONARD AND FROST
    1    1    1   17    7    2      0.50
    1    1
   12    2
   16    2
    1     2.700    20.000     1.540
    2     2.65     19.300     0.900
      8.00    0    1
      1.00      3.00      3.00    0
    1      3.00      15.00      70.00
    2      5.00      20.00     100.00
```

b. Output Data, File VDOU.DAT

```
      FOOTING IN GRANULAR SOIL - LEONARD AND FROST

NUMBER OF PROBLEMS=    1     NUMBER OF NODAL POINTS=   17
NUMBER OF NODAL POINT AT BOTTOM OF FOUNDATION=          7
NUMBER OF DIFFERENT SOIL LAYERS=    2     INCREMENT DEPTH=      0.50  FT

         LEONARDS AND FROST MODEL

         RECTANGULAR SLAB FOUNDATION

DEPTH OF FOUNDATION =                  3.00  FEET
TOTAL DEPTH OF THE SOIL PROFILE =      8.00  FEET
```

Table F-5. Continued

ELEMENT	NUMBER OF SOIL
1	1
2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1
11	1
12	2
13	2
14	2
15	2
16	2

MATERIAL	SPECIFIC GRAVITY	WATER CONTENT, %	VOID RATIO
1	2.700	20.000	1.540
2	2.650	19.300	0.900

DEPTH TO WATER TABLE = 8.00 FEET

DISPLACEMENTS AT EACH DEPTH OUTPUT

EQUILIBRIUM SATURATED PROFILE ABOVE WATER TABLE

APPLIED PRESSURE ON FOUNDATION= 1.00 TSF
LENGTH = 3.00 FEET WIDTH = 3.00 FEET

CENTER OF FOUNDATION

MATERIAL	A PRESSURE, TSF	B PRESSURE, TSF	CONE RESISTANCE, TSF
1	3.00	15.00	70.00
2	5.00	20.00	100.00

QNET= 0.88041

ELEMENT	DEPTH, FT	SETTLEMENT, FT	KO	QC/SIGV	PHI, DEGREES
7	3.25	-0.00017	1.66	540.32	44.52
8	3.75	-0.00033	1.49	468.28	44.10
9	4.25	-0.00053	1.36	413.19	43.67
10	4.75	-0.00068	1.25	369.69	43.26
11	5.25	-0.00071	1.17	334.49	42.88

Table F-5. Concluded

12	5.75	-0.00152	1.69	430.59	43.68
13	6.25	-0.00150	1.56	387.24	43.32
14	6.75	-0.00142	1.45	351.82	42.98
15	7.25	-0.00127	1.36	322.33	42.67
16	7.75	-0.00104	1.28	297.41	42.39

SETTLEMENT BENEATH FOUNDATION= -0.00918 FEET

Table F-6

Settlement of Granular Soil, Schmertmann Model

a. Input data, file VDIN.DAT

```
       FOOTING IN GRANULAR SOIL - SCHMERTMANN
    1    2    1   17    7    2      0.50
    1    1
   12    2
   16    2
    1     2.700    20.000     1.540
    2     2.65     19.300     0.900
      8.00    0    1
      1.00      3.00      3.00    0
    1     70.00
    2    100.00
    3     10.00
```

b. Output Data, File VDOU.DAT

```
      FOOTING IN GRANULAR SOIL - SCHMERTMANN

NUMBER OF PROBLEMS=    1     NUMBER OF NODAL POINTS=   17
NUMBER OF NODAL POINT AT BOTTOM OF FOUNDATION=          7
NUMBER OF DIFFERENT SOIL LAYERS=    2     INCREMENT DEPTH=      0.50  FT

         SCHMERTMANN MODEL

         RECTANGULAR SLAB FOUNDATION

DEPTH OF FOUNDATION =                  3.00  FEET
TOTAL DEPTH OF THE SOIL PROFILE =      8.00  FEET
ELEMENT    NUMBER OF SOIL

   1            1
   2            1
   3            1
   4            1
   5            1
```

Table F-6. Concluded

6	1
7	1
8	1
9	1
10	1
11	1
12	2
13	2
14	2
15	2
16	2

MATERIAL	SPECIFIC GRAVITY	WATER CONTENT, %	VOID RATIO
1	2.700	20.000	1.540
2	2.650	19.300	0.900

DEPTH TO WATER TABLE = 8.00 FEET

DISPLACEMENTS AT EACH DEPTH OUTPUT

EQUILIBRIUM SATURATED PROFILE ABOVE WATER TABLE

APPLIED PRESSURE ON FOUNDATION= 1.00 TSF
LENGTH = 3.00 FEET WIDTH = 3.00 FEET

CENTER OF FOUNDATION

MATERIAL	CONE RESISTANCE, TSF
1	70.00
2	100.00

TIME AFTER CONSTRUCTION IN YEARS= 10.00

ELEMENT	DEPTH, FT	SETTLEMENT, FT
7	3.25	-0.00069
8	3.75	-0.00138
9	4.25	-0.00205
10	4.75	-0.00222
11	5.25	-0.00193
12	5.75	-0.00115
13	6.25	-0.00096
14	6.75	-0.00078
15	7.25	-0.00060
16	7.75	-0.00042

SETTLEMENT BENEATH FOUNDATION= -0.01218 FEET

c. Settlement of Collapsible Soil. The granular soil of the preceding problem was tested in a one-dimensional consolidometer to check for collapse potential. The results of this test were plotted in a compression curve diagram similar to Figure 5-5 and indicated the settlement points shown in Table F-7a, input data for program VDISPL. The output data shown in Table F-7b indicate potential collapse of 0.33 ft or 4 inches beneath the footing.

F-4. Listing. A listing of this program is provided in Table F-8.

Table E-7

Collapse Potential

a. Input data, file VDIN.DAT

```
       FOOTING IN GRANULAR SOIL - SCHMERTMANN
    1    3    1   17    7    2      0.50
    1    1
   12    2
   16    2
    1     2.700    20.000     1.540
    2     2.65     19.300     0.900
      8.00    0    1
      1.00      3.00      3.00    0
    1      0.01      0.40      1.00      1.00      4.00
    2      0.05      0.40      1.00      1.00      4.00
    1      0.00      1.00      2.00     10.00     15.00
    2      0.00      0.80      1.50      8.00     12.00
```

b. Output Data, File VDOU.DAT

```
      FOOTING IN GRANULAR SOIL - SCHMERTMANN

NUMBER OF PROBLEMS=    1     NUMBER OF NODAL POINTS=   17
NUMBER OF NODAL POINT AT BOTTOM OF FOUNDATION=          7
NUMBER OF DIFFERENT SOIL LAYERS=    2     INCREMENT DEPTH=      0.50  FT

         COLLAPSIBLE SOIL

         RECTANGULAR SLAB FOUNDATION

DEPTH OF FOUNDATION =                  3.00  FEET
TOTAL DEPTH OF THE SOIL PROFILE =      8.00  FEET
ELEMENT    NUMBER OF SOIL
   1           1
   2           1
   3           1
   4           1
   5           1
   6           1
   7           1
```

Table F-7. Continued

8	1
9	1
10	1
11	1
12	2
13	2
14	2
15	2
16	2

MATERIAL	SPECIFIC GRAVITY	WATER CONTENT, %	VOID RATIO
1	2.700	20.000	1.540
2	2.650	19.300	0.900

DEPTH TO WATER TABLE = 8.00 FEET

DISPLACEMENTS AT EACH DEPTH OUTPUT

EQUILIBRIUM SATURATED PROFILE ABOVE WATER TABLE

APPLIED PRESSURE ON FOUNDATION= 1.00 TSF
LENGTH = 3.00 FEET WIDTH = 3.00 FEET

CENTER OF FOUNDATION

APPLIED PRESSURE AT 5 POINTS IN UNITS OF TSF

MATERIAL	A	BB	B	C	D
1	0.01	0.40	1.00	1.00	4.00
2	0.05	0.40	1.00	1.00	4.00

STRAIN AT 5 POINTS IN PERCENT

MATERIAL	A	BB	B	C	D
1	0.00	1.00	2.00	10.00	15.00
2	0.00	0.80	1.50	8.00	12.00

COLLAPSE DISTRIBUTION ABOVE FOUNDATION DEPTH

ELEMENT	DEPTH,FT	DELTA,FT
1	0.25	0.00007
2	0.75	-0.02081
3	1.25	-0.03052
4	1.75	-0.03691
5	2.25	-0.04169
6	2.75	-0.07354

COLLAPSE DISTRIBUTION BELOW FOUNDATION

Table F-7. Concluded

ELEMENT	DEPTH,FT	DELTA,FT
7	3.25	-0.07999
8	3.75	-0.07955
9	4.25	-0.07834
10	4.75	-0.07674
11	5.25	-0.07516
12	5.75	-0.05423
13	6.25	-0.05269
14	6.75	-0.05171
15	7.25	-0.05119
16	7.75	-0.05104

SOIL COLLAPSE NEXT TO FOUNDATION EXCLUDING COLLAPSE
IN SUBSOIL BENEATH FOUNDATION = -0.10171 FEET
SUBSOIL COLLAPSE = -0.32532 FEET
TOTAL COLLAPSE = -0.42702 FEET

Table F-8

Listing of Program VDISPL

```
C     PREDICTION OF VERTICAL MOVEMENT, PROGRAM VDISPL.FOR
C     DEVELOPED BY L. D. JOHNSON
C     INPUT PARAMETERS
C       1ST LINE: NAME OF PROBLEM                          (20A4)
C       2ND LINE: NPROB  NOPT  NBPRES  NNP  NBX  NMAT  DX    (6I5,F10.2)
C       3RD LINE: N  IE(N,M)                               (2I5)
C     3RD LINE REPEATED FOR EACH NEW MATERIAL; LAST LINE IS NEL    NMAT
C       4TH LINE: M  G(M)  WC(M)  EO(M)                    (I5,3F10.3)
C     4TH LINE REPEATED FOR EACH NEW LAYER  M  UNTIL  M=NMAT
C       5TH LINE: DGWT  IOPTION  NOUT                      (F10.2,2I5)
C       6TH LINE: Q,BLEN,BWID,MRECT                        (3F10.2,I5)
C       7TH LINE: IF(NOPT.EQ.0) M SP(M) CS(M) CC(M) PM(M)    (I5,4F10.2)
C       7TH LINE: IF(NOPT.EQ.1) M PO(M) P1(M) QC(M)        (I5,3F10.2)
C       7TH LINE: IF(NOPT.EQ.2 OR 4) M QC(M)               (I5,F10.2)
C       7TH LINE: IF(NOPT.EQ.3) M PRES(M,J),J=1,5          (I5,5F10.2)
C     7TH LINE REPEATED FOR EACH DIFFERENT MATERIAL M UNTIL M=NMAT
C       8TH LINE: IF(NOPT.EQ.0) XA  XF                     (2F10.2)
C       8TH LINE: IF(NOPT.EQ.2.OR 4) TIME                  (F10.2)
C       8TH LINE: IF(NOPT.EQ.3) M STRA(M,J),J=1,5          (I5,5F10.2)
C     ABOVE LINE REPEATED FOR EACH DIFFERENT MATERIAL UNTIL M=NMAT
C     DESCRIPTION OF INPUT PARAMETERS
C         NAME OF PROBLEM  Insert title of your problem
C         NPROB   number of problems to solve with different active zone
C                 depths,groundwater level, moisture profile, and
C                 foundation dimensions
```

Table F-8. Continued

```
C         NOPT    Option for model, =0 for consolidation swell (MECH)
C                     =1 for Leonards and Frost
C                     =2 for Schmertmann
C                     =3 for Collapsible soil
C                     =4 for elastic soil settlement
C         NBPRES  Option for foundation, =1 for rectangular slab and
C                 =2 for long strip footing
C         NNP     Total number of nodal points
C         NBX     Number of nodal point at bottom of foundation
C         NMAT    Total number of different soil layers, < 10
C         DX      Increment of depth, ft
C         N       Element number
C         IE(N,1) Number of soil layer  M  associated with element  N
C         M       Number of soil layer
C         G(M)    Specific gravity of soil layer  M
C         WC(M)   Water content of soil layer  M, Percent
C         EO(M)   Initial void ratio of soil layer  M
C         DGWT    Depth to hydrostatic water table, ft; If IOPTION =2,
C                 set DGWT=XA+UWA/0.03125 where UWA= suction (or
C                 positive value of the negative pore water pressure) at
C                 depth XA
C         IOPTION Equilibrium moisture profile, = 0 for saturation above
C                 the water table; if NOPT=0, then =1 for hydrostatic
C                 with shallow water table, method 2 or =2 for
C                 hydrostatic without shallow water table
C         NOUT    Amount of output data, =0 only heave computations and
C                   =1  for heave and pore pressure at each depth
C                       increment
C         Q       Applied pressure on foundation, tsf
C         BLEN    Length of foundation or 0.0 if NBPRES = 2, feet
C         BWID    Width of foundation or long continuous footing, feet
C         MRECT   Location of calculation, =0 for center and =1
C                 for corner of rectangle or edge of long footing
C         SP(M)   Swell pressure of soil layer  M, tsf
C         CS(M)   Swell index of soil layer  M
C         CC(M)   Compression index of soil layer  M
C         PM(M)   Maximum past pressure, tsf
C         PO(M)   Dilatometer A pressure, tsf
C         P1(M)   Dilatometer B pressure, tsf
C         QC(M)   If NOPT=2, cone penetration resistance, tsf
C                 If NOPT=4, elastic soil modulus, tsf
C         PRES(M) Applied pressure at 5 points from collapsible soil,tsf
C         STRA(M) Strain at 5 points from collapsible soil
C         XA      Depth of active zone of heave, feet
C         XF      Depth from ground surface to the depth that the active
C                 zone begins, feet
C         TIME    Time in years after Construction for Schmertmann model
      PARAMETER (NL=30,NQ=101)
      COMMON/SLA/P(NQ),IE(NQ,1),EO(NL),DX,NBX,NEL,PII,NOUT
      DIMENSION PP(NQ),G(NL),WC(NL),HED(20)
```

Table F-8. Continued

```
      OPEN(5,FILE='VDIN.DAT')
      OPEN(6,FILE='VDOU.DAT')
      READ(5,1) (HED(I),I=1,20)
      WRITE(6,1) (HED(I),I=1,20)
    1 FORMAT(20A4)
      GAW=0.03125
      PII=3.14159265
      NP=1
      READ(5,2) NPROB,NOPT,NBPRES,NNP,NBX,NMAT,DX
    2 FORMAT(6I5,F10.2)
      WRITE(6,3) NPROB,NNP,NBX,NMAT,DX
    3 FORMAT(/,1X,'NUMBER OF PROBLEMS=',I5,5X,'NUMBER OF NODAL POINTS='
     1,I5,/,1X,'NUMBER OF NODAL POINT AT BOTTOM OF FOUNDATION=',I11,/,1X
     2,'NUMBER OF DIFFERENT SOIL LAYERS=',I5,5X,'INCREMENT DEPTH=',F10.2
     3,'  FT',/)
      IF(NOPT.EQ.0)WRITE(6,4)
    4 FORMAT(10X,'CONSOLIDATION SWELL MODEL',/)
      IF(NOPT.EQ.1)WRITE(6,5)
    5 FORMAT(10X,'LEONARDS AND FROST MODEL',/)
      IF(NOPT.EQ.2)WRITE(6,6)
    6 FORMAT(10X,'SCHMERTMANN MODEL',/)
      IF(NOPT.EQ.3)WRITE(6,7)
    7 FORMAT(10X,'COLLAPSIBLE SOIL',/)
      IF(NOPT.EQ.4)WRITE(6,8)
    8 FORMAT(10X,'ELASTIC SOIL',/)
      IF(NBPRES.EQ.1)WRITE(6,9)
    9 FORMAT(10X,'RECTANGULAR SLAB FOUNDATION',/)
      IF(NBPRES.EQ.2)WRITE(6,10)
   10 FORMAT(10X,'LONG CONTINUOUS STRIP FOUNDATION',/)
      DEPF=DX*FLOAT(NBX-1)
      WRITE(6,11)DEPF
   11 FORMAT(1X,'DEPTH OF FOUNDATION =',12X,F10.2,'  FEET')
      DEPPR = DX*FLOAT(NNP-1)
      WRITE(6,12)DEPPR
   12 FORMAT(1X,'TOTAL DEPTH OF THE SOIL PROFILE =',F10.2,'  FEET')
      NEL=NNP-1
      L=0
      WRITE(6,21)
   21 FORMAT(1X,'ELEMENT    NUMBER OF SOIL',/)
   22 READ(5,2)N,IE(N,1)
   25 L=L+1
      IF(N-L)35,35,30
   30 IE(L,1)=IE(L-1,1)
      WRITE(6,32)L,IE(L,1)
   32 FORMAT(I5,8X,I5)
      GOTO 25
   35 WRITE(6,32)L,IE(L,1)
      IF(NEL-L)40,40,22
   40 CONTINUE
      WRITE(6,390)
```

Table F-8. Continued

```
  390 FORMAT(/,1X,'MATERIAL   SPECIFIC GRAVITY   WATER CONTENT, %   ',
     1'VOID RATIO',/)
  400 READ(5,401) M,G(M),WC(M),EO(M)
  401 FORMAT(I5,3F10.3)
      IF(NMAT-M)403,405,400
  403 WRITE(6,404) M
  404 FORMAT(/,5X,'ERROR IN MATERIAL', I5)
      STOP
  405 DO 410 M=1,NMAT
      WRITE(6,407) M,G(M),WC(M),EO(M)
  407 FORMAT(I5,3F18.3)
  410 CONTINUE
 1000 READ(5,45) DGWT,IOPTION,NOUT
   45 FORMAT(F10.2,2I5)
      READ(5,46)Q,BLEN,BWID,MRECT
   46 FORMAT(3F10.2,I5)
      WRITE(6,50) DGWT
   50 FORMAT(1X,'DEPTH TO WATER TABLE =',11X,F10.2,'  FEET',/)
      IF(NOUT.EQ.1)WRITE(6,51)
      IF(NOUT.EQ.0)WRITE(6,52)
   51 FORMAT(1X,'DISPLACEMENTS AT EACH DEPTH OUTPUT',/)
   52 FORMAT(1X,'TOTAL DISPLACEMENTS ONLY',/)
      IF(IOPTION.EQ.0.OR.NOPT.EQ.1)WRITE(6,61)
   61 FORMAT(1X,'EQUILIBRIUM SATURATED PROFILE ABOVE WATER TABLE',/)
      IF(IOPTION.EQ.1.AND.NOPT.EQ.0)WRITE(6,62)
   62 FORMAT(1X,'EQUILIBRIUM HYDROSTATIC PROFILE ABOVE WATER TABLE',/)
      WRITE(6,90)Q,BLEN,BWID
   90 FORMAT(/,1X,'APPLIED PRESSURE ON FOUNDATION=',F10.2,' TSF',/,1X,
     1'LENGTH =',F10.2,'  FEET',5X,'WIDTH =',F10.2,'  FEET',/)
      IF(MRECT.EQ.0)WRITE(6,91)
   91 FORMAT(9X,'CENTER OF FOUNDATION',/)
      IF(MRECT.EQ.1)WRITE(6,92)
   92 FORMAT(9X,'CORNER OF SLAB OR EDGE OF LONG STRIP FOOTING',/)
C          CALCULATION OF EFFECTIVE OVERBURDEN PRESSURE
  105 P(1)=0.0
      PP(1)=0.0
      DXX=DX
      DO 110 I=2,NNP
      MTYP=IE(I-1,1)
      WCC=WC(MTYP)/100.
      GAMM=G(MTYP)*GAW*(1.+WCC)/(1.+EO(MTYP))
      IF(DXX.GT.DGWT)GAMM=GAMM-GAW
      P(I)=P(I-1)+DX*GAMM
      PP(I)=P(I)
      DXX=DXX+DX
  110 CONTINUE
      IF(NOPT.NE.0.OR.IOPTION.EQ.0)GOTO 120
      MO=IFIX(DGWT/DX)
      IF(MO.GT.NNP)MO=NNP
      DO 117 I=1,MO
```

Table F-8. Continued

```
      BN=DGWT/DX-FLOAT(I-1)
      P(I)=P(I)+BN*DX*GAW
  117 CONTINUE
  120 CALL SLAB(Q,BLEN,BWID,MRECT,NBPRES,PP(NBX))
C           CALCULATION OF MOVEMENT FROM MODELS
      IF(NOPT.EQ.0) CALL MECH(NMAT)
      IF(NOPT.EQ.1) CALL LEON(Q,NMAT,DGWT,BWID,PP,NBPRES)
      IF(NOPT.EQ.2) CALL SCHMERT(Q,NMAT,DGWT,BWID,PP,NBPRES,2)
      IF(NOPT.EQ.3) CALL COLL(NMAT)
      IF(NOPT.EQ.4) CALL SCHMERT(Q,NMAT,DGWT,BWID,PP,NBPRES,4)
      NP=NP+1
      IF(NP.GT.NPROB) GOTO 200
      GOTO 1000
  200 CLOSE(5,STATUS='KEEP')
      CLOSE(6,STATUS='KEEP')
      STOP
      END
C
C
      SUBROUTINE MECH(NMAT)
      PARAMETER(NL=30,NQ=101)
      COMMON/SLA/P(NQ),IE(NQ,1),EO(NL),DX,NBX,NEL,PII,NOUT
      DIMENSION SP(NL),CS(NL),CC(NL),PM(NL)
      WRITE(6,5)
    5 FORMAT(/,1X,'MATERIAL   SWELL PRESSURE,    SWELL       COMPRESSION
     1   MAXIMUM PAST',/,1X,'                 TSF           INDEX
     2  INDEX      PRESSURE,TSF',/)
      DO 10 I = 1,NMAT
      READ(5,11) M,SP(M),CS(M),CC(M),PM(M)
      IF(PM(M).LT.SP(M)) WRITE(6,14) SP(M),PM(M)
      IF(PM(M).LT.SP(M)) PM(M)=SP(M)
      WRITE(6,24)M,SP(M),CS(M),CC(M),PM(M)
   10 CONTINUE
   11 FORMAT(I5,4F10.4)
   14 FORMAT(/,1X,'SWELL PRESSURE',F10.2,'  WAS SET GREATER THAN MAXIM',
     1'UM PAST PRESSURE',F10.2,/,1X,'WHICH IS NOT POSSIBLE; SWELL PRESSU
     2RE SET EQUAL TO MAXIMUM PAST PRESSURE',/)
   24 FORMAT(1X,I5,4F15.3)
C
      READ(5,30)XA,XF
   30 FORMAT(2F10.2)
      WRITE(6,31) XA,XF
   31 FORMAT(/,8X,'ACTIVE ZONE DEPTH (FT) =',F10.2,/,1X,'DEPTH ACTIVE ZO
     1NE BEGINS (FT) =',F10.2,/)
      DELH1=0.0
      DXX=0.0
      CALL PSAD(N1,N2,XA,XF,DXX,DX,NBX)
      IF(N1.GE.N2) GOTO 50
      IF(NOUT.EQ.0) GOTO 50
      WRITE(6,32)
```

Table F-8. Continued

```
   32 FORMAT(/,1X,'HEAVE DISTRIBUTION ABOVE FOUNDATION DEPTH',/,1X,'ELEM
     1ENT    DEPTH,FT    DELTA HEAVE,FT    EXCESS PORE PRESSURE,TSF',/)
      DO 40 I=N1,N2
      MTYP=IE(I,1)
      PR=(P(I)+P(I+1))/2.
      CA=SP(MTYP)/PR
      CB=SP(MTYP)/PM(MTYP)
      CBB=PM(MTYP)/PR
      E=EO(MTYP)+CS(MTYP)*ALOG10(CA)
      IF(PR.GT.PM(MTYP)) E=EO(MTYP)+CS(MTYP)*ALOG10(CB)+CC(MTYP)*ALOG10
     1(CBB)
      DEL=(E-EO(MTYP))/(1.+EO(MTYP))
      IF(NOUT.EQ.0) GOTO 36
      DELP=SP(MTYP)-PR
      WRITE(6,110) I,DXX,DEL,DELP
   36 DELH1=DELH1+DX*DEL
      DXX=DXX+DX
   40 CONTINUE
   50 DELH2=0.0
      IF(NBX.GT.NEL) GOTO 120
      DXX=FLOAT(NBX)*DX-DX/2.
      IF(NOUT.EQ.0) GOTO 65
      WRITE(6,60)
   60 FORMAT(/,1X,'HEAVE DISTRIBUTION BELOW FOUNDATION',/,1X,'ELEMENT
     1 DEPTH,FT    DELTA HEAVE,FT    EXCESS PORE PRESSURE,TSF',/)
   65 DO 100 I=NBX,NEL
      MTYP=IE(I,1)
      PR=(P(I)+P(I+1))/2.
      CA=SP(MTYP)/PR
      CB=SP(MTYP)/PM(MTYP)
      CBB=PM(MTYP)/PR
      E=EO(MTYP)+CS(MTYP)*ALOG10(CA)
      IF(PR.GT.PM(MTYP))E=EO(MTYP)+CS(MTYP)*ALOG10(CB)+CC(MTYP)*ALOG10
     1(CBB)
      DEL=(E-EO(MTYP))/(1.+EO(MTYP))
      IF(NOUT.EQ.0) GOTO 80
      DELP=SP(MTYP)-PR
      WRITE(6,110) I,DXX,DEL,DELP
   80 DELH2=DELH2+DX*DEL
      DXX=DXX+DX
  100 CONTINUE
  110 FORMAT(I5,F13.2,F18.5,5X,F18.5)
      DEL1=DELH1+DELH2
      WRITE(6,305) DELH1,DELH2,DEL1
  305 FORMAT(/,1X,'SOIL HEAVE NEXT TO FOUNDATION EXCLUDING HEAVE',/,1X,
     1'IN SUBSOIL BENEATH FOUNDATION =',F8.5,'  FEET',//,14X,'SUBSOIL ',
     2'MOVEMENT =',F8.5,'  FEET',/,19X,'TOTAL HEAVE =',F8.5,'  FEET')
  120 RETURN
      END
C
```

Table F-8. Continued

```
C
      SUBROUTINE SLAB(Q,BLEN,BWID,MRECT,NBPRES,WT)
      PARAMETER (NL=30,NQ=101)
      COMMON/SLA/P(NQ),IE(NQ,1),EO(NL),DX,NBX,NEL,PII,NOUT
C
C       CALCULATION OF SURCHARGE PRESSURE FROM STRUCTURE
C
      NNP=NEL+1
      ANBX=FLOAT(NBX)*DX
      DXX=0.0
      BPRE1=Q-WT
      BPRES=BPRE1
      DO 100 I=NBX,NNP
      IF(DXX.LT.0.01) GOTO 80
      MTYP=IE(I-1,1)
      IF(NBPRES.EQ.2) GOTO 70
      BL=BLEN
      BW=BWID
      BPR=BPRES
      IF(MRECT.EQ.1) GOTO 50
      BL=BLEN/2.
      BW=BWID/2.
   50 VE2=(BL**2.+BW**2.+DXX**2.)/(DXX**2.)
      VE=VE2**0.5
      AN=BL*BW/(DXX**2.)
      AN2=AN**2.
      ENM=(2.*AN*VE/(VE2+AN2))*(VE2+1.)/VE2
      FNM=2.*AN*VE/(VE2-AN2)
      IF(MRECT.EQ.1)BPR=BPRES/4.
      AB=ATAN(FNM)
      IF(FNM.LT.0.) AB=PII+AB
      P(I)=P(I)+BPR*(ENM+AB)/PII
      GOTO 90
   70 DB=DXX/BWID
      PS=-0.157-0.22*DB
      IF(MRECT.EQ.0.AND.DB.LT.2.5)PS=-0.28*DB
      PS=10.**PS
      P(I)=P(I)+BPRES*PS
      GOTO 90
   80 P(I)=P(I)+BPRES
   90 DXX=DXX+DX
  100 CONTINUE
      RETURN
      END
C
C
C
      SUBROUTINE PSAD(N1,N2,XA,XF,DXX,DX,NBX)
      AN1=XF/DX
      AN2=XA/DX
```

Table F-8. Continued

```
      N1=IFIX(AN1)+1
      N2=AN2
      DXX=XF+DX/2.
      N3=NBX-1
      IF(N2.GT.N3)N2=N3
      CONTINUE
      RETURN
      END
C
C
      SUBROUTINE LEON(Q,NMAT,DGWT,BWID,PP,NBPRES)
      PARAMETER(NL=30,NQ=101)
      COMMON/SLA/P(NQ),IE(NQ,1),EO(NL),DX,NBX,NEL,PII,NOUT
      DIMENSION PO(NL),P1(NL),QC(NL),PP(NQ)
      WRITE(6,5)
    5 FORMAT(/,1X,'MATERIAL   A PRESSURE, TSF   B PRESSURE, TSF   CONE
     1RESISTANCE, TSF',/)
      DO 10 I = 1,NMAT
      READ(5,15)M,PO(M),P1(M),QC(M)
      WRITE(6,20)M,PO(M),P1(M),QC(M)
   10 CONTINUE
   15 FORMAT(I5,3F10.2)
   20 FORMAT(I5,3F18.2)
      CALL SPLINE
      NNP=NEL+1
      GAW=0.03125
      DELH=0.0
      DEL=0.0
      QNET=Q-PP(NBX)
      WRITE(6,17)QNET
   17 FORMAT(/,1X,'QNET=',F10.5)
      DXX=DX*FLOAT(NBX) - DX/2.
      C1=1 - 0.5*PP(NBX)/QNET
      IF(C1.LT.0.5) C1=0.5
      IF(NOUT.EQ.0) GOTO 30
      WRITE(6,25)
   25 FORMAT(/,1X,'ELEMENT  DEPTH,   SETTLEMENT,     KO    QC/SIGV  PHI,
     1 DEGREES',/,1X,'            FT          FT',/)
   30 DO 300 I=NBX,NEL
      MTYP=IE(I,1)
      PR1=(PP(I+1)+PP(I))/2.
      PR=(P(I+1)+P(I))/2.
      UW=0.0
      IF(DXX.GT.DGWT) UW=(DXX-DGWT)*GAW
      AKD = (PO(MTYP)-UW)/PR1
      AID = (P1(MTYP)-PO(MTYP))/(PO(MTYP)-UW)
      ED = 34.7*(P1(MTYP)-PO(MTYP))
      RQC = QC(MTYP)/PR1
      AKO=0.376+0.095*AKD-0.0017*RQC
      EC = AKO
```

Table F-8. Continued

```
      S3 = RQC
      MM=0
      UC=0.0
      CALL BICUBE(UC,EC,S3)
      S3=RQC
      PHIPS=UC*PII/180.
      AKA = (1-SIN(PHIPS))/(1+SIN(PHIPS))
      AKP = (1+SIN(PHIPS))/(1-SIN(PHIPS))
      AAK = AKO
      IF(AKO.LE.AKA)AAK=AKA
      IF(AKO.GE.AKP)AAK=AKP
      IF(ABS(AAK-AKO).GT.0.01)EC=AAK
      IF(ABS(AAK-AKO).GT.0.01) CALL BICUBE(UC,EC,S3)
      S3=RQC
      PHIAX=UC
      IF(UC.GT.32.0) PHIAX=UC-((UC-32.)/3.)
      PHI=PHIAX*PII/180.
      OCR=(AAK/(1-SIN(PHI)))**(1./(0.8*SIN(PHI)))
      PM=OCR*PR1
      ROC=(PM-PR1)/(PR-PR1)
      IF(ROC.LT.0.0)ROC=0.0
      RNC=(PR-PM)/(PR-PR1)
      IF(RNC.LT.0.0)RNC=0.0
      IF(NBPRES.EQ.2) GOTO 100
      ANN=0.5*BWID/DX + DX*FLOAT(NBX-1)
      NN=IFIX(ANN)
      SIGM=PR1
      AIZP=0.5+0.1*(QNET/SIGM)**0.5
      DEPT=DXX-FLOAT(NBX-1)*DX
      AIZ=0.1+(AIZP-0.1)*DEPT/(0.5*BWID)
      IF(DEPT.GT.0.5*BWID)AIZ=AIZP+AIZP/3.0-AIZP*DEPT/(1.5*BWID)
      IF(DEPT.GT.2*BWID)AIZ=0.0
      GOTO 200
  100 ANN=BWID/DX + DX*FLOAT(NBX-1)
      NN=IFIX(ANN)
      SIGM=PR1
      AIZP=0.5+0.1*(QNET/SIGM)**0.5
      DEPT=DXX-FLOAT(NBX-1)*DX
      AIZ=0.2+(AIZP-0.2)*DEPT/BWID
      IF(DEPT.GT.BWID)AIZ=AIZP+AIZP/3.-AIZP*DEPT/(3.*BWID)
      IF(DEPT.GT.4*BWID)AIZ=0.0
  200 F=0.7
      IF(ROC.LE.0.0)F=0.9
      DEL=-C1*QNET*AIZ*DX*(ROC/(3.5*ED)+RNC/(F*ED))
      DELH=DELH+DEL
      IF(NOUT.EQ.1)WRITE(6,310)I,DXX,DEL,EC,S3,UC
      DXX=DXX+DX
  300 CONTINUE
  310 FORMAT(I5,F10.2,F13.5,3F10.2)
      WRITE(6,320) DELH
```

Table F-8. Continued

```
  320 FORMAT(/,1X,'SETTLEMENT BENEATH FOUNDATION=',F10.5,'  FEET',/)
      RETURN
      END
C
C
      BLOCK DATA
      DIMENSION XX(100),YY(100),U(100)
      COMMON/SPL/XX,YY,U
      DATA(XX(I),I=1,99,11)/9*10./,(XX(I),I=2,99,11)/9*20./,(XX(I),I=3,
     199,11)/9*30./,(XX(I),I=4,99,11)/9*50./,(XX(I),I=5,99,11)/9*100./,
     2(XX(I),I=6,99,11)/9*200./,(XX(I),I=7,99,11)/9*300./,(XX(I),I=8,99,
     311)/9*500./,(XX(I),I=9,99,11)/9*1000./,(XX(I),I=10,99,11)/9*2000./
     4,(XX(I),I=11,99,11)/9*3000./
      DATA(YY(I),I=1,11)/11*0.16/,(YY(I),I=12,22)/11*0.20/,(YY(I),I=23,
     133)/11*0.4/,(YY(I),I=34,44)/11*0.6/,(YY(I),I=45,55)/11*0.8/,(YY(I)
     2,I=56,66)/11*1.0/,(YY(I),I=67,77)/11*2.0/,(YY(I),I=78,88)/11*4./,
     3(YY(I),I=89,99)/11*6./
      DATA(U(I),I=1,99)/25.,30.1,33.2,36.4,39.9,42.8,44.4,46.,48.5,50.5,
     152.,24.8,30.,33.,36.2,39.7,42.6,44.2,45.8,48.2,50.2,51.5,24.5,29.7
     2,32.6,35.6,39.3,42.1,43.7,45.4,47.5,49.7,51.,24.2,29.5,32.2,35.1,
     338.8,41.7,43.3,45.,47.2,49.,50.,24.,29.2,31.7,34.7,38.4,41.4,42.9,
     444.6,46.8,48.6,49.7,23.8,28.8,31.5,34.4,38.,41.,42.5,44.3,46.5,48.
     54,49.5,23.,27.5,30.,33.,36.6,39.6,41.2,43.,45.4,47.2,48.4,22.,26.,
     628.3,31.2,34.5,37.7,39.7,41.5,43.7,45.7,47.,21.,25.,27.2,30.,33.8,
     736.,38.2,40.3,42.7,44.8,46.1/
      END
C
C
      SUBROUTINE SPLINE
C     SPLINE TO CALCULATE VARIABLES
      DIMENSION XX(100),YY(100),U(100)
      COMMON/SPL/XX,YY,U
      COMMON/SPLIN/X(100),Y(100),S(100)
      COMMON/BICUB/UX(100),UY(100),UXY(100)
      NCONF=11
      NSTR=9
      NCT=1
      N=NCONF
  210 ID=NCONF*NCT
      II=ID-NCONF+1
      JJ=NCONF-1
      DO 220 I=II,ID
      J=NCONF-JJ
      X(J)=XX(I)
      Y(J)=U(I)
  220 JJ=JJ-1
      CALL SOLV(N)
      IC=1
      DO 225 I=II,ID
      UX(I)=S(IC)
```

Table F-8. Continued

```
  225 IC=IC+1
      NCT=NCT+1
      IF(NCT.LE.NSTR)GO TO 210
      NCT=1
      N=NSTR
  230 IT=NCONF*(NSTR-1)
      ID=IT+NCT
      II=ID-IT
      JJ=NSTR-1
      DO 235 I=II,ID,NCONF
      J=NSTR-JJ
      X(J)=YY(I)
      Y(J)=U(I)
  235 JJ=JJ-1
      CALL SOLV(N)
      IC=1
      DO 240 I=II,ID,NCONF
      UY(I)=S(IC)
  240 IC=IC+1
      NCT=NCT+1
      IF(NCT.LE.NCONF)GO TO 230
      NCT=1
      N=NCONF
  243 ID=NCONF*NCT
      II=ID-NCONF+1
      JJ=NCONF-1
      DO 245 I=II,ID
      J=NCONF-JJ
      X(J)=XX(I)
      Y(J)=UY(I)
  245 JJ=JJ-1
      CALL SOLV(N)
      IC=1
      DO 250 I=II,ID
      UXY(I)=S(IC)
  250 IC=IC+1
  300 FORMAT(I5,F15.5)
      NCT=NCT+1
      IF(NCT.LE.NSTR)GO TO 243
      RETURN
      END
C
C
C
      SUBROUTINE SOLV(N)
      COMMON/SPLIN/X(100),Y(100),S(100)
      DIMENSION A(100),B(100),C(100),D(100),F(100),GG(100),H(100)
      N1=N-1
      DO 2010 I=2,N
 2010 H(I)=X(I)-X(I-1)
```

Table F-8. Continued

```
      DO 2020 I=2,N
 2020 A(I)=1./H(I)
      A(1)=0.
      DO 2030 I=2,N1
      T1=1./H(I)+1./H(I+1)
 2030 B(I)=2.*T1
      B(1)=2.*(1./H(2))
      B(N)=2.*(1./H(N))
      DO 2040 I=1,N1
 2040 C(I)=1./H(I+1)
      C(N)=0.
      DO 2050 I=2,N1
      T1=(Y(I)-Y(I-1))/(H(I)*H(I))
      T2=(Y(I+1)-Y(I))/(H(I+1)*H(I+1))
 2050 D(I)=3.*(T1+T2)
      T1=(Y(2)-Y(1))/(H(2)*H(2))
      D(1)=3.*T1
      T2=(Y(N)-Y(N-1))/(H(N)*H(N))
      D(N)=3.*T2
C     FORWARD PASS
      GG(1)=C(1)/B(1)
      DO 2100 I=2,N1
      T1=B(I)-A(I)*GG(I-1)
 2100 GG(I)=C(I)/T1
      F(1)=D(1)/B(1)
      DO 2110 I=2,N
      TEM=D(I)-A(I)*F(I-1)
      T1=B(I)-A(I)*GG(I-1)
 2110 F(I)=TEM/T1
C     BACK SOLUTION
      S(N)=F(N)
      I=N-1
 2120 S(I)=F(I)-GG(I)*S(I+1)
      IF(I.EQ.1) GOTO 2150
      I=I-1
      GO TO 2120
 2150 CONTINUE
      RETURN
      END
C
C
      SUBROUTINE BICUBE(UC,EC,S3)
      DIMENSION XX(100),YY(100),U(100)
      COMMON/SPL/XX,YY,U
      COMMON/BICUB/UX(100),UY(100),UXY(100)
      DIMENSION H(16),KE(100,4)
      DATA((KE(K,I),I=1,4),K=1,10)/1,2,13,12,2,3,14,13,3,4,15,14,4,5,16,
     115,5,6,17,16,6,7,18,17,7,8,19,18,8,9,20,19,9,10,21,20,10,11,22,21/
      DATA((KE(K,I),I=1,4),K=11,20)/12,13,24,23,13,14,25,24,14,15,26,25,
     115,16,27,26,16,17,28,27,17,18,29,28,18,19,30,29,19,20,31,30,20,21,
```

Table F-8. Continued

```
     232,31,21,22,33,32/
      DATA((KE(K,I),I=1,4),K=21,30)/23,24,35,34,24,25,36,35,25,26,37,36,
     126,27,38,37,27,28,39,38,28,29,40,39,29,30,41,40,30,31,42,41,31,32,
     243,42,32,33,44,43/
      DATA((KE(K,I),I=1,4),K=31,40)/34,35,46,45,35,36,47,46,36,37,48,47,
     137,38,49,48,38,39,50,49,39,40,51,50,40,41,52,51,41,42,53,52,42,43,
     254,53,43,44,55,54/
      DATA((KE(K,I),I=1,4),K=41,50)/45,46,57,56,46,47,58,57,47,48,59,58,
     148,49,60,59,49,50,61,60,50,51,62,61,51,52,63,62,52,53,64,63,53,54,
     265,64,54,55,66,65/
      DATA((KE(K,I),I=1,4),K=51,60)/56,57,68,67,57,58,69,68,58,59,70,69,
     159,60,71,70,60,61,72,71,61,62,73,72,62,63,74,73,63,64,75,74,64,65,
     276,75,65,66,77,76/
      DATA((KE(K,I),I=1,4),K=61,70)/67,68,79,78,68,69,80,79,69,70,81,80,
     170,71,82,81,71,72,83,82,72,73,84,83,73,74,85,84,74,75,86,85,75,76,
     287,86,76,77,88,87/
      DATA((KE(K,I),I=1,4),K=71,80)/78,79,90,89,79,80,91,90,80,81,92,91,
     181,82,93,92,82,83,94,93,83,84,95,94,84,85,96,95,85,86,97,96,86,87,
     298,97,87,88,99,98/
      DO 400 M=1,80
      I=KE(M,1)
      J=KE(M,2)
      K=KE(M,3)
      L=KE(M,4)
      IF(S3.GE.XX(I).AND.S3.LE.XX(J))GOTO 410
      GOTO 400
  410 IF(EC.GE.YY(I).AND.EC.LE.YY(L))GOTO 420
  400 CONTINUE
  420 CONTINUE
      AA=XX(J)-XX(I)
      BB=YY(L)-YY(I)
      S3N=S3-XX(I)
      ECN=EC-YY(I)
      SL=S3N/AA
      T=ECN/BB
      S2=SL*SL
      S3=SL*SL*SL
      T2=T*T
      T3=T2*T
      F1=1.-3.*S2+2.*S3
      F2=S2*(3.-2.*SL)
      F3=AA*SL*(1.-SL)*(1.-SL)
      F4=AA*S2*(SL-1.)
      DO 430 KJ=1,2
      G1=1.-3.*T2+2.*T3
      G2=T2*(3.-2.*T)
      G3=BB*T*(1.-T)*(1.-T)
      G4=BB*T2-2.*T
      H(1)=F1*G1*U(I)
      H(2)=F2*G1*U(J)
```

Table F-8. Continued

```
      H(3)=F2*G2*U(K)
      H(4)=F1*G2*U(L)
      H(5)=F3*G1*UX(I)
      H(6)=F4*G1*UX(J)
      H(7)=F4*G2*UX(K)
      H(8)=F3*G2*UX(L)
      H(9)=F1*G3*UY(I)
      H(10)=F2*G3*UY(J)
      H(11)=F2*G4*UY(K)
      H(12)=F1*G4*UY(L)
      H(13)=F3*G3*UXY(I)
      H(14)=F4*G4*UXY(J)
      H(15)=F4*G4*UXY(K)
      H(16)=F3*G4*UXY(L)
      UC=0.0
      DO 480 KK=1,16
  480 UC=UC+H(KK)
  430 CONTINUE
      RETURN
      END
C
C
      SUBROUTINE SCHMERT(Q,NMAT,DGWT,BWID,PP,NBPRES,JOPT)
      PARAMETER(NL=30,NQ=101)
      COMMON/SLA/P(NQ),IE(NQ,1),EO(NL),DX,NBX,NEL,PII,NOUT
      DIMENSION QC(NL),PP(NQ)
      IF(JOPT.EQ.2)WRITE(6,5)
    5 FORMAT(/,1X,'MATERIAL   CONE RESISTANCE, TSF',/)
      IF(JOPT.EQ.4)WRITE(6,6)
    6 FORMAT(/,1X,'MATERIAL   ELASTIC MODULUS, TSF',/)
      DO 10 I = 1,NMAT
      READ(5,15)M,QC(M)
      WRITE(6,20)M,QC(M)
   10 CONTINUE
   15 FORMAT(I5,F10.2)
   20 FORMAT(I5,F18.2)
      READ(5,30)TIME
   30 FORMAT(F10.2)
      WRITE(6,35)TIME
   35 FORMAT(/,1X,'TIME AFTER CONSTRUCTION IN YEARS=',F10.2,/)
      NNP=NEL+1
      DELH=0.0
      DEL=0.0
      QNET=Q-PP(NBX)
      DXX=DX*FLOAT(NBX) - DX/2.
      C1=1 - 0.5*PP(NBX)/QNET
      IF(C1.LT.0.5) C1=0.5
      FF=TIME/0.1
      CT=1+0.2*ALOG10(FF)
      IF(NOUT.EQ.0) GOTO 40
```

Table F-8. Continued

```
      WRITE(6,25)
   25 FORMAT(/,1X,'ELEMENT    DEPTH, FT    SETTLEMENT, FT ',/)
   40 DO 300 I=NBX,NEL
      MTYP=IE(I,1)
      PR1=(PP(I+1)+PP(I))/2.
      ESI=QC(MTYP)
      IF(NBPRES.EQ.1.AND.JOPT.EQ.2)ESI=2.5*QC(MTYP)
      IF(NBPRES.EQ.2.AND.JOPT.EQ.2)ESI=3.5*QC(MTYP)
      IF(NBPRES.EQ.2) GOTO 100
      ANN=0.5*BWID/DX + DX*FLOAT(NBX-1)
      NN=IFIX(ANN)
      SIGM=PR1
      AIZP=0.5+0.1*(QNET/SIGM)**0.5
      DEPT=DXX-FLOAT(NBX-1)*DX
      AIZ=0.1+(AIZP-0.1)*DEPT/(0.5*BWID)
      IF(DEPT.GT.0.5*BWID)AIZ=AIZP+AIZP/3.0-AIZP*DEPT/(1.5*BWID)
      IF(DEPT.GT.2*BWID)AIZ=0.0
      GOTO 200
  100 ANN=BWID/DX + DX*FLOAT(NBX-1)
      NN=IFIX(ANN)
      SIGM=PR1
      AIZP=0.5+0.1*(QNET/SIGM)**0.5
      DEPT=DXX-FLOAT(NBX-1)*DX
      AIZ=0.2+(AIZP-0.2)*DEPT/BWID
      IF(DEPT.GT.BWID)AIZ=AIZP+AIZP/3.-AIZP*DEPT/(3.*BWID)
      IF(DEPT.GT.4*BWID)AIZ=0.0
  200 DEL=-C1*CT*QNET*AIZ*DX/ESI
      DELH=DELH+DEL
      IF(NOUT.EQ.1)WRITE(6,310)I,DXX,DEL
      DXX=DXX+DX
  300 CONTINUE
  310 FORMAT(I5,F13.2,F18.5)
      WRITE(6,320) DELH
  320 FORMAT(/,1X,'SETTLEMENT BENEATH FOUNDATION=',F10.5,'  FEET',/)
      RETURN
      END
C
C
      SUBROUTINE COLL(NMAT)
      PARAMETER(NL=30,NQ=101)
      COMMON/SLA/P(NQ),IE(NQ,1),EO(NL),DX,NBX,NEL,PII,NOUT
      DIMENSION PRES(NL,5),STRA(NL,5)
      WRITE(6,5)
    5 FORMAT(/,10X,'APPLIED PRESSURE AT 5 POINTS IN UNITS OF TSF',/,1X,'
     1MATERIAL    A         BB         B         C         D',/)
      DO 10 I = 1,NMAT
      READ(5,11) M,(PRES(M,J),J=1,5)
      WRITE(6,11)M,(PRES(M,J),J=1,5)
   10 CONTINUE
   11 FORMAT(I5,5F10.2)
```

Table F-8. Continued

```
      WRITE(6,15)
   15 FORMAT(/,10X,'STRAIN AT 5 POINTS IN PERCENT',/1X,'MATERIAL    A
     1       BB         B         C        D',/)
      DO 20 I=1,NMAT
      READ(5,21) M,(STRA(M,J),J=1,5)
      WRITE(6,21)M,(STRA(M,J),J=1,5)
      DO 19 K=1,5
      STRA(M,K) = STRA(M,K)/100.
   19 CONTINUE
   20 CONTINUE
   21 FORMAT(I5,5F10.2)
      DELH1=0.0
      DXX=DX/2.
      IF(NBX.EQ.1) GOTO 50
      IF(NOUT.EQ.0) GOTO 50
      WRITE(6,32)
   32 FORMAT(/,1X,'COLLAPSE DISTRIBUTION ABOVE FOUNDATION DEPTH',/,1X,'E
     1LEMENT    DEPTH,FT        DELTA,FT',/)
      DO 40 I=1,NBX-1
      MTY=IE(I,1)
      PR=(P(I)+P(I+1))/2.
      PRA=PRES(MTY,2)/PRES(MTY,1)
      PRB=PRES(MTY,3)/PRES(MTY,2)
      PRC=PRES(MTY,4)/PRES(MTY,1)
      PRD=PRES(MTY,5)/PRES(MTY,4)
      PRE=PRES(MTY,1)/PR
      PRF=PRES(MTY,2)/PR
      PRG=PRES(MTY,4)/PR
      SA=(STRA(MTY,2)-STRA(MTY,1))/ALOG10(PRA)
      SB=(STRA(MTY,3)-STRA(MTY,2))/ALOG10(PRB)
      SC=(STRA(MTY,4)-STRA(MTY,1))/ALOG10(PRC)
      SD=(STRA(MTY,5)-STRA(MTY,4))/ALOG10(PRD)
      IF(PR.LE.PRES(MTY,2))DEB=-STRA(MTY,1)+SA*ALOG10(PRE)
      IF(PR.GT.PRES(MTY,2))DEB=-STRA(MTY,2)+SB*ALOG10(PRF)
      IF(PR.LE.PRES(MTY,4))DEA=-STRA(MTY,1)+SC*ALOG10(PRE)
      IF(PR.GT.PRES(MTY,4))DEA=-STRA(MTY,4)+SD*ALOG10(PRG)
      DEL=DEA-DEB
      IF(NOUT.EQ.0) GOTO 36
      WRITE(6,110) I,DXX,DEL
   36 DELH1=DELH1+DX*DEL
      DXX=DXX+DX
   40 CONTINUE
   50 DELH2=0.0
      IF(NBX.GT.NEL) GOTO 120
      DXX=FLOAT(NBX)*DX-DX/2.
      IF(NOUT.EQ.0) GOTO 65
      WRITE(6,60)
   60 FORMAT(/,1X,'COLLAPSE DISTRIBUTION BELOW FOUNDATION',/,1X,'ELEMENT
     1   DEPTH,FT        DELTA,FT',/)
   65 DO 100 I=NBX,NEL
```

Table F-8. Concluded

```
      MTY=IE(I,1)
      PR=(P(I)+P(I+1))/2.
      PRA=PRES(MTY,2)/PRES(MTY,1)
      PRB=PRES(MTY,3)/PRES(MTY,2)
      PRC=PRES(MTY,4)/PRES(MTY,1)
      PRD=PRES(MTY,5)/PRES(MTY,4)
      PRE=PRES(MTY,1)/PR
      PRF=PRES(MTY,2)/PR
      PRG=PRES(MTY,4)/PR
      SA=(STRA(MTY,2)-STRA(MTY,1))/ALOG10(PRA)
      SB=(STRA(MTY,3)-STRA(MTY,2))/ALOG10(PRB)
      SC=(STRA(MTY,4)-STRA(MTY,1))/ALOG10(PRC)
      SD=(STRA(MTY,5)-STRA(MTY,4))/ALOG10(PRD)
      IF(PR.LE.PRES(MTY,2))DEB=-STRA(MTY,1)+SA*ALOG10(PRE)
      IF(PR.GT.PRES(MTY,2))DEB=-STRA(MTY,2)+SB*ALOG10(PRF)
      IF(PR.LE.PRES(MTY,4))DEA=-STRA(MTY,1)+SC*ALOG10(PRE)
      IF(PR.GT.PRES(MTY,4))DEA=-STRA(MTY,4)+SD*ALOG10(PRG)
      DEL=DEA-DEB
      IF(NOUT.EQ.0) GOTO 80
      WRITE(6,110) I,DXX,DEL
   80 DELH2=DELH2+DX*DEL
      DXX=DXX+DX
  100 CONTINUE
  110 FORMAT(I5,F13.2,F18.5)
      DEL1=DELH1+DELH2
      WRITE(6,305) DELH1,DELH2,DEL1
  305 FORMAT(/,1X,'SOIL COLLAPSE NEXT TO FOUNDATION EXCLUDING COLLAPSE',
     1/,1X,'IN SUBSOIL BENEATH FOUNDATION =',F10.5,' FEET',/,1X,'SUBSOIL
     2 COLLAPSE =',F10.5,' FEET',/,1X,'TOTAL COLLAPSE =',F10.5,' FEET')
  120 RETURN
      END
```