YOUNGSTOWN STATE UNIVERSITY

DEVELOPMENT OF DESIGN GRAPHS FOR CANTILEVER AND ANCHORED STEEL SHEET PILES

A THESIS SUBMITTED TO

THE GRADUATE FACULTY OF THE SCHOOL OF CIVIL ENGINEERING

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ABSTRACT

The purpose of this thesis was to develop graphs to simplify the design of steel sheet pile walls. There are two basic types of steel sheet pile walls: cantilever and anchored walls. For cantilevered walls, the pile is driven to a sufficient depth into the ground to become fixed as a vertical cantilever in resisting the lateral active earth pressure. This type of wall is commonly restricted to a maximum height of 15 feet. Anchored walls also derive support by passive pressure on the front of the embedment pile portion as the cantilever wall. Support is also contributed from the anchor tie rods near the top of the piling. This method is suitable for heights up to approximately 35 feet, depending on the soil conditions.

Sheet pile design can be a rather time consuming, cumbersome effort to a practicing engineer. The usual objective is to determine the pile's minimum embedment depth, bending moment and anchor pull force frequently for varying soil conditions.

Four cases for sheet piles were analysed which include:

- Cantilever with granular backfill and granular subsoil;
- Cantilever with granular backfill and cohesive subsoil;
- Anchored with granular backfill and granular subsoil; and,
- Anchored with granular backfill and cohesive subsoil.

A computer program was written in BASIC to aid in the trial and error solutions for individual sheet pile problems.

Design graphs were developed for the respective analytical expressions for pile embedment depth, bending moment and anchor force for various soil conditions and water levels. Hence, the graphs will greatly reduce the length of time required to size a sheet pile and improve the accuracy of calculation.

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LIST OF SYMBOLS

Symbol	Description	English Units	S.I. Units
ϕ	Friction angle of backfill	Degrees	Degrees
c	Cohesion of subsoil	psf	kN/m^2
γ_b	Buoyant density of backfill	pcf	kN/m^3
γ	Wet density of backfill	pcf	kN/m^3
K_a	Coefficient of active pressure		
K_p	Coefficient of passive pressure		
a	Depth to zero pressure	ft	m
Y	Distance from bottom of pile to point of zero shear	ft	m
D	Minimum pile embedment depth	ft	m
H	Pile height above dredge line	ft	m
h_w	Depth to saturated backfill	ft	m
q	Effective soil pressure at dredge line	psf	kN/m^2
p_a	Unit backfill active force	psf	kN/m^2
p_p'	Unit subsoil passive force	psf	kN/m^2
R_a	Resultant of active forces of backfill or subsoil	lbs/ft	kn/m
y	Distance from centroid of active forces to point of zero shear	ft	m
Mmax	Maximum bending moment	ft-lbs/ft	kN-m/m
T	Anchor pull force	lbs/ft	kN/m
α	Ratio of [vertical distance from ground surface to water table] / H		

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CHAPTER 1

INTRODUCTION

Cantilever and anchored steel sheet pile design can be very complex. Once the soil shear strength properties are determined through laboratory testing, the practicing engineer must calculate the active backfill forces and maximum moment on the pile. The minimum pile embedment depth is then determined by trial and error solution of a cumbersome equation. To simplify these design problems, Teng (USS 1975, Figures 18, 22, 24 & 26) had developed a few graphs to aid the engineer in such design. Use of the graphs greatly reduces the time required to determine the pile's minimum embedment depth, anchor pull force and maximum moment for a given set of soil and water table conditions. However, Teng developed graphs for only one type of soil buoyant density (γ_b). Teng's graphs (USS 1975, Figures 18, 22, 24 & 26) are for γ_b equal to one-half the wet density (γ) for the backfill soil.

Four cases (1) Cantilever with granular backfill and granular subsoil; (2) Cantilever with granular backfill and cohesive subsoil; (3) Anchored with granular backfill and granular subsoil; (4) Anchored with granular backfill and cohesive subsoil) for sheet piles were analysed for minimum embedment depth, anchor pull (if applicable) and maximum moment, as outlined on Table 1. Theoretical expressions for each case were derived and discussed in Sections 2.0 through 5.0.

A computer program was written in BASIC to aid in trial and error solutions. The program is developed to analyze either English or S.I. data input. This program listing is in Appendix A. The soil's active coefficient (K_a) and passive coefficient (K_p) are based on Coulumb's method.

Calculated results were then plotted for comparison to graphs developed by Teng (USS 1975, Figures 18, 22, 24 & 26). As indicated previously, Teng had derived graphs for only buoyant (saturated) soil densities equal to one-half the wet density. Hence, the comparison is only applicable to these graphs (USS 1975, Figures 18, 22, 24 & 26). Refer to Figures 1, 4, 7 and 10 for this author's rederived graphs. Here, graphs were also developed for γ_b of 0.4 and 0.6 to cover a broader range of saturated soils.

CHAPTER 2

CANTILEVER STEEL SHEET PILE, GRANULAR SUBSOIL AND GRANULAR BACKFILL

Two equations will be used to determine the pile embedment depth and moment for granular subsoil and backfill loading conditions.

2.1 Case 1

Analysis was performed with program PILE.4, using the following minimum pile depth equation derived in Section 2.1.1 and summarized in Section 2.1.2.

2.1.1 Derivations

Determine the pile embedment depth and moment equations for granular subsoil and backfill loading conditions.

Step 1 Find the unit backfill active force, p_a, at the dredge line and depth to zero pressure, a, shown on Figure 2-1.

$$p_a = K_a \left[\gamma h_w + \gamma_b (H - h_w) \right] \qquad \text{(eq 1)}$$

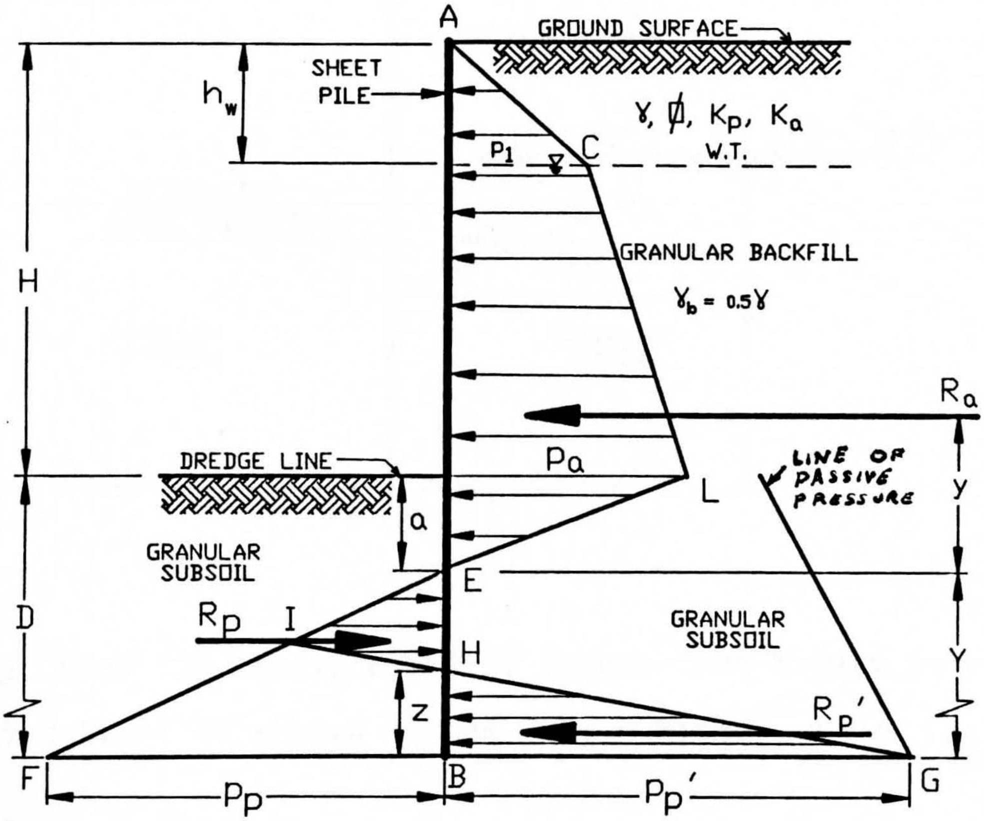
H = Pile height above dredge line
h_w = Depth to saturated backfill

K_a = Coefficient of active pressure
= $\tan^2 (45 - \phi/2)$
γ_b = Buoyant density of backfill material
γ = Wet density of backfill material

$$a = p_a / [\gamma_b (K_p - K_a)] \qquad \text{(eq 2)}$$

K_p = Coefficient of passive pressure
= $\tan^2 (45 + \phi/2)$

Figure 2-1



Step 2 Find the unit subsoil passive force, p_p, at the bottom of the pile shown on Figure 2-1.

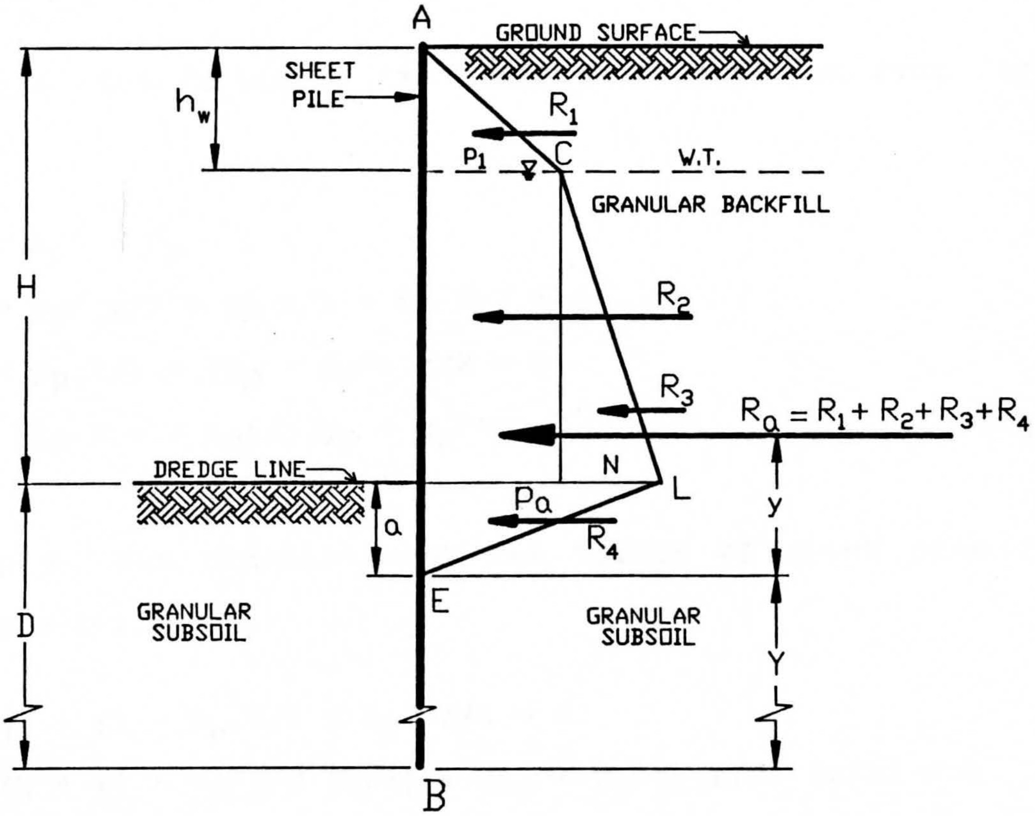
$p_a / a = p_p / Y$

substitute a

$p_a / [p_a / [\gamma_b (K_p - K_a)]] = p_p / Y$

$$p_p = \gamma_b (K_p - K_a) Y \qquad \text{(eq 3)}$$

Figure 2-2



Step 3 Find the active backfill forces from Figure 2-2.

R_a = Resultant of active forces = $R_1 + R_2 + R_3 + R_4$ (eq 4)

$R_1 = .5\ \gamma\ h_w^2\ K_a$
$R_2 = P_1\ (H - h_w)$
$\quad = \gamma\ h_w\ K_a\ (H - h_w)$
$R_3 = .5N\ (H - h_w)$
$\quad N = p_a - P_1$
$\quad\quad = \gamma_b\ K_a\ (H - h_w)$
$\quad = .5\gamma_b\ K_a\ (H - h_w)^2$
$R_4 = .5p_a\ a$

Step 4 Find the centroid, y, of R_a from Figure 2-2.

Y = Distance from centroid of active forces to point of zero shear

$$y = [R_1 (a + H - .67h_w) + R_2 [a + .5(H - h_w)] + R_3 [a + .33(H - h_w)] + .67R_4\, a]/ R_a \qquad \text{(eq 5)}$$

Step 5 Sum forces in the horizontal direction from Figure 2-1.

$$R_a + R_p' - R_p = 0$$

$$R_a + p_p' z/2 + p_p z/2 - p_p Y/2 = 0$$

$$R_a - p_p Y/2 + (p_p + p_p') z/2 = 0$$

$$z = (p_p Y - 2 R_a)/ (p_p + p_p') \qquad \text{(eq 6)}$$

Step 6 Sum moments about the bottom of sheet pile from Figure 2-1.

$$R_a (Y + y) - R_p Y/3 + R_p' z/3 = 0$$

$$R_a (Y + y) - p_p Y/2 (Y/3) + (p_p + p_p') (z/2) (z/3) = 0$$

$$6R_a (Y + y) - p_p Y^2 + (p_p + p_p') z^2 = 0 \qquad \text{(eq 7)}$$

Step 7 Substitute equation 6 into equation 7.

$$6R_a (Y + y) - p_p Y^2 + (p_p + p_p') [(p_p Y - 2R_a)/ (p_p + p_p')]^2 = 0$$

$$6R_a (Y + y) - p_p Y^2 + (p_p^2 Y^2 - 4p_p Y R_a + 4R_a^2/ (p_p + p_p') = 0$$

let $CY = p_p = b (K_p - K_a) Y$

multiply by $(p_p + p_p')$ or $(CY + p_p')$

$$6R_a (Y + y) (CY + p_p') - CY Y^2 (CY + p_p') + (C^2 Y^2 Y^2 - 4CY Y R_a + 4R_a^2) = 0$$

$$6R_a (CY^2 + p_p' Y + CY y + p_p' y) - C^2 Y^4 - p_p' CY^3 + C^2 Y^4 - 4CY^2 R_a + 4R_a^2 = 0$$

divide by C

$$-p_p' \, Y^3 + 2R_a \, Y^2 + 6R_a \, (p_p'/C + y) \, Y + (2R_a/C) \, (3p_p' \, y + 2R_a) = 0$$

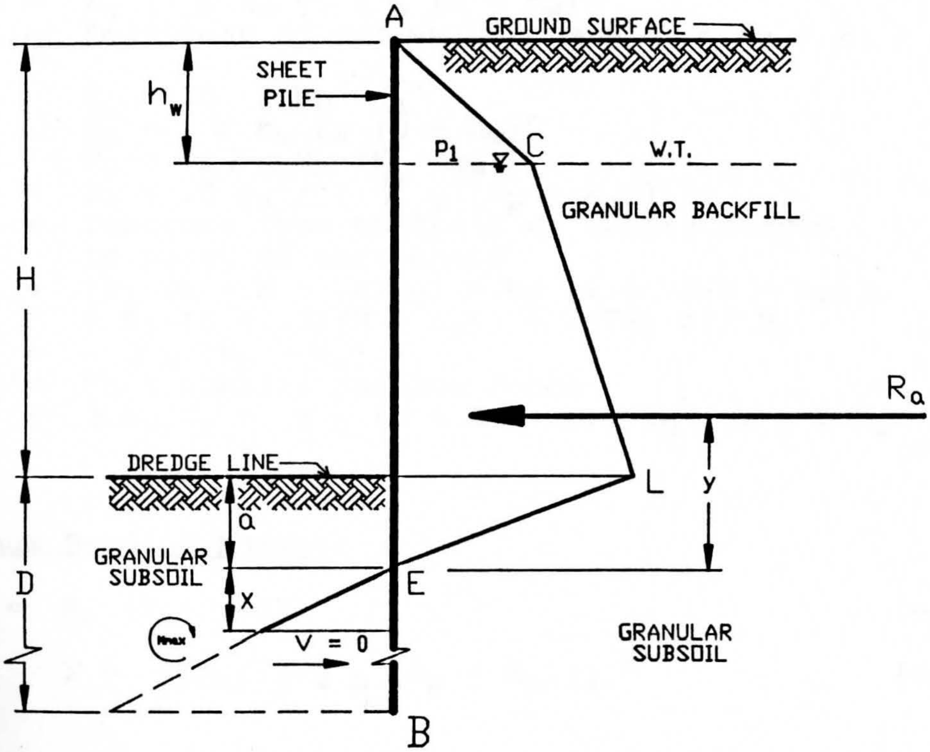
$$Y^3 - (2R_a/ \, p_p') \, Y^2 - 6R_a \, [(y/p_p') + (1/C)] \, Y - (2R_a/ \, Cp_p') \, (2R_a + 3p_p' \, y) = 0 \qquad \text{(eq 8)}$$

where:

$$p_p' = \gamma \, h_w \, K_p + \gamma_b \, (H + D - h_w)] \, K_p - \gamma_b \, D \, K_a$$

__Step 8__ Find the maximum moment for the sheet pile from Figure 2-3, which occurs where the shear, v, is equal to zero.

Figure 2-3



$$M_{max} = R_a \, (y + .67X) \qquad \text{(eq 9)}$$

where:

$$X = [2R_a/ \, [\, \gamma_b \, (K_p - K_a)]]^{.5}$$

2.1.2 Summary of Equations

<u>Minimum Embedment Depth:</u>

$$Y^3 - (2R_a/p_p') Y^2 - 6R_a [(y/p_p') + (1/C)] Y - (2R_a/ C p_p') (2R_a + 3p_p' y) = 0 \quad \text{(eq 2-1)}$$

Y = Distance from bottom of pile to point of zero shear or $Y = D - a$ (eq 2-2)

D = Minimum pile embedment depth

H = Pile height above dredge line

h_w = Depth to saturated backfill

K_p = Coefficient of passive pressure

= $\tan^2 (45 + \phi/2)$ (eq 2-3)

K_a = Coefficient of active pressure

= $\tan^2 (45 - \phi/2)$ (eq 2-4)

γ_b = Buoyant density of backfill

γ = Wet density of backfill

a = Depth to zero pressure

= $p_a/ [\gamma_b (K_p - K_a)]$ (eq 2-5)

p_a = Unit backfill active force

= $K_a [\gamma h_w + \gamma_b (H - h_w)]$ (eq 2-6)

R_a = Resultant of active forces = $R_1 + R_2 + R_3 + R_4$ (eq 2-7)

$R_1 = .5 \gamma h_w^2 K_a$

$R_2 = \gamma h_w K_a (H - h_w)$

$R_3 = .5 \gamma_b K_a (H - h_w)^2$

$R_4 = .5 p_a^2/ [\gamma_b (K_p - K_a)]$

y = Distance from centroid of active forces to point of zero shear

= $[R_1 (a + H - .67h_w) + R_2 [a + .5(H - h_w)] + R_3 [a + .33(H - h_w)] + .67R_4 a]/ R_a$ (eq 2-8)

C = $\gamma_b (K_p - K_a) Y$ (eq 2-9)

p_p' = Unit subsoil passive force

= $\gamma h_w K_p + \gamma_b (H + D - h_w)] K_p + \gamma_b D K_a$ (eq 2-10)

<u>Maximum Bending Moment:</u>

$$M_{max} = R_a (Y + .67X) \quad \text{(eq 2-11)}$$

$$X = [2R_a/ [\gamma_b (K_p - K_a)]]^{.5} \quad \text{(eq 2-12)}$$

2.1.3 Example Problems

Six problems were solved using PILE.4 program, Option 1 selection. These problems are included in Appendix B, Sheets 1 through 6 and are summarized in Table 1. The backfill's friction angle ranged from 30 to 35 degrees for these problems. Minimum pile depth results deviated from the authors' solutions (Bowles 1982 & Das 1983) by 0.0 to 2.9 percent (six solutions) and maximum moment deviated by 9.8 percent (one solution).

2.1.4 Design Graph ($\gamma_b = .5 \gamma$)

PILE.4 program, Option 2 selection was used to develop Figure 1. Computer computations were calculated in the English system and are included in Appendix C. Six solutions are summarized in Table 2, for alpha (α) equals 0, 0.5 and 1.0. Alpha is the ratio of [vertical distance from the ground surface to the water table] / [height of backfill]. The backfill's friction angle selected is 28 and 37 degrees from the graph data. At a zero degree backfill slope the K_p/K_a ratios are 7.67 and 16.18, respectively.

Minimum pile depth ratio (D/H) results deviated from Teng's graph (USS 1975, Figure 18) by 0.0 to 1.4 percent and maximum moment ratio ($Mmax/ \gamma_b K_a H^3$) deviated by 0.0 percent. Data results are plotted on semi-logarithmic paper on Figure 1 with three available programs (AutoCAD Rel 10, GRAPHER Ver 1.79E, Lotus 1-2-3 Rel 3). PILE.4 program calculates and saves data points in a PRN extension file. This data is included in Appendix C. LOTUS 1-2-3 (Lotus 1-2-3 Rel 3) is then used to import the data file. The file rows and columns were rearranged in an ASCI format suitable with a DAT extension for the GRAPHER (GRAPHER Ver 1.79E) program. A DXF plot file is then created by GRAPHER for insertion into AutoCAD (AutoCAD Rel 10). The drawing file is created in AutoCAD and rearranged for output to a Hewlett Packer Pen Plotter.

2.1.5 New Graphs ($\gamma b = .4 \gamma$, $.6 \gamma$)

Two new graphs were developed for various soil conditions and water levels. These include Figures 2 and 3 for a backfill buoyant density of $\gamma b = .4 \gamma$ and $.6 \gamma$, respectively.

TABLE 1
CASE 1 SUMMARY
OPTION 1
CANTILEVER STEEL SHEET PILE
GRANULAR SUBSOIL AND GRANULAR BACKFILL

PROBLEM	REF	SYSTEM	FRICTION ANGLE	MINIMUM EMBEDMENT DEPTH, D			BACKFILL ACTIVE FORCE, R_a			MAXIMUM MOMENT, Mmax		
				TEXT (1)	PILE.4	DEVIATION	TEXT (1)	PILE.4	DEVIATION	TEXT (1)	PILE.4	DEVIATION
13−6A	1	English	30° (2)	20 ft	20.1 ft	0.0 %	8,860 lbs/ft	8,871 lbs/ft	0.1 %	NA	135,982 ft−lb/ft	−−
13−6D	1	S.I.	33° (2)	5.33 m	5.31 m	0.0 %	119.2 kN/m	119.0 kN/m	0.0 %	NA	515.8 kN−m/m	−−
ex 13−1	1	English	30° (2)	16.65 ft	16.8 ft	0.9 %	6,300 lbs/ft	6,264 lbs/ft	−0.6 %	NA	78,392 ft−lbs/ft	−−
ex 6.1	2	S.I.	32°	5.46 m	5.42 m	0.7 %	58.3 kN/m	58.3 kN/m	0.0 %	190.7 kN−m/m	209.5 kN−m/m	9.8 %
6.1	2	English	35°	23.5 ft	22.8 ft	−2.9 %	NA	6,087 lbs/ft	−−	NA	96,975 ft−lbs/ft	−−
6.3	2	English	32°	27.3 ft	27.3 ft	0.0 %	NA	9,594.9 lbs/ft	−−	NA	173,204 ft−lbs/ft	−−

Notes:
1. These answers are from the referenced text books.
2. The wall friction is 17 degrees for this problem.

References:

1. Bowles, Joseph E. 1982, Foundation Analysis and Design, 3rd edition.
2. Das, Braja 1983, Advanced Foundation Design.

TABLE 2
CASE 1 SUMMARY
OPTION 2
CANTILEVER STEEL SHEET PILE
GRANULAR SUBSOIL AND GRANULAR BACKFILL

α RATIO	K_p/K_a RATIO	FRICTION ANGLE	DEPTH RATIO			MOMENT RATIO		
			GRAPH (1)	PILE.4	DEVIATION	GRAPH (1)	PILE.4	DEVIATION
0	7.67	28°	1.10	1.11	0.9 %	0.40	0.40	0.0 %
0	16.18	37°	0.70	0.71	1.4 %	0.29	0.29	0.0 %
0.5	7.67	28°	1.48	1.49	0.6 %	0.92	0.92	0.0 %
0.5	16.18	37°	0.92	0.92	0.0 %	0.63	0.63	0.0 %
1.0	7.67	28°	1.68	1.69	0.6 %	1.23	1.23	0.0 %
1.0	16.18	37°	1.01	1.01	0.0 %	0.77	0.77	0.0 %

Notes:
1. α Ratio = γ_b/γ = Buoyant Density/ Wet Density
2. K_p/K_a Ratio = Passive Coefficient/ Active Coefficient
3. Depth Ratio = D/ H = Minimum Pile Embedment Depth/ Pile Height Above Dredge Line
4. Moment Ratio = Mmax/ $\gamma_b K_a H^3$
   Mmax = Maximum Moment

Reference:

1. United States Steel Corporation July 1975, Steel Sheet Piling Design Manual, Figure 18.

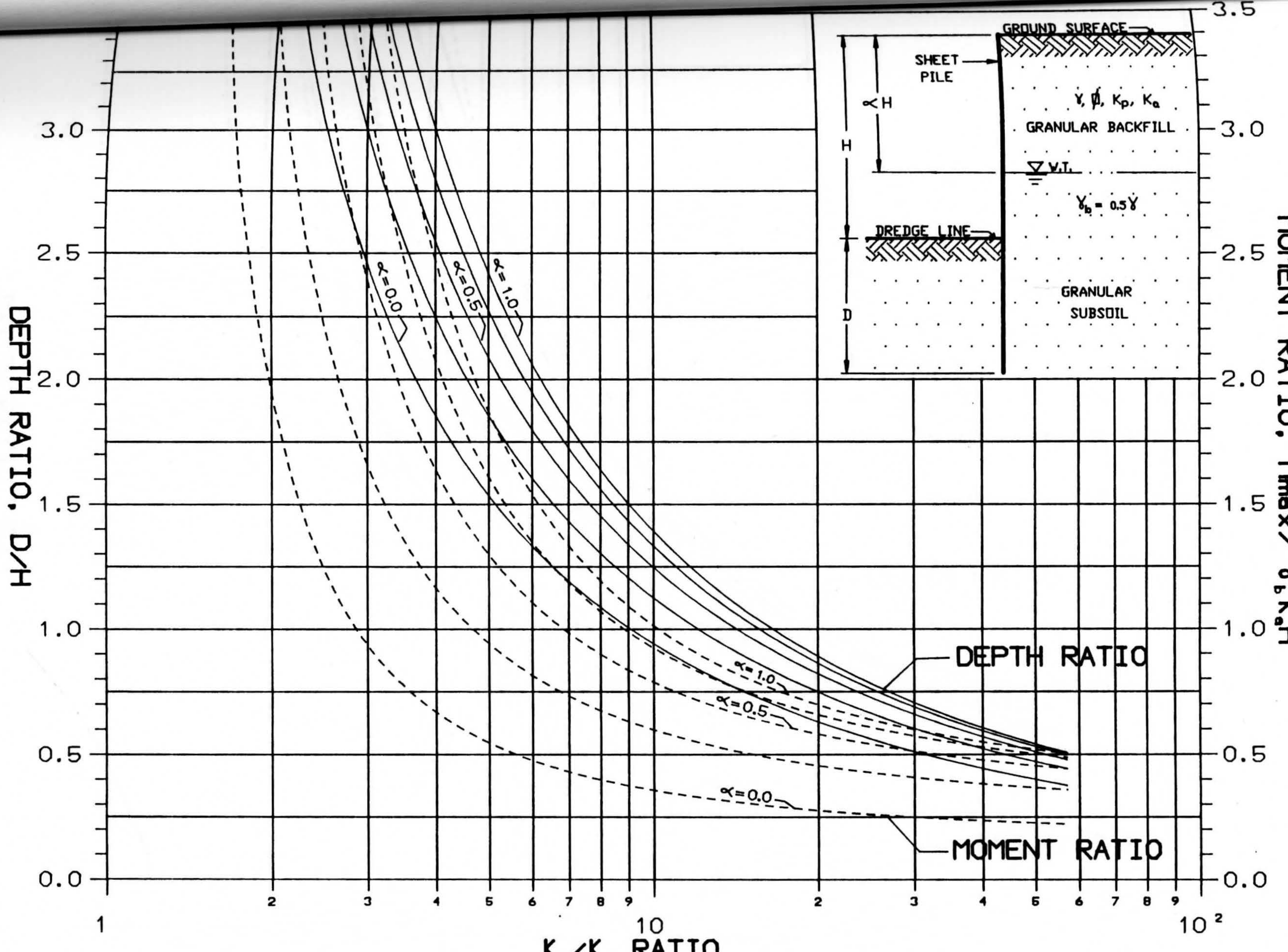


FIGURE 1
CANTILEVER STEEL SHEET PILE
GRANULAR SUBSOIL WITH GRANULAR BACKFILL
$\gamma_b = 0.5\gamma$

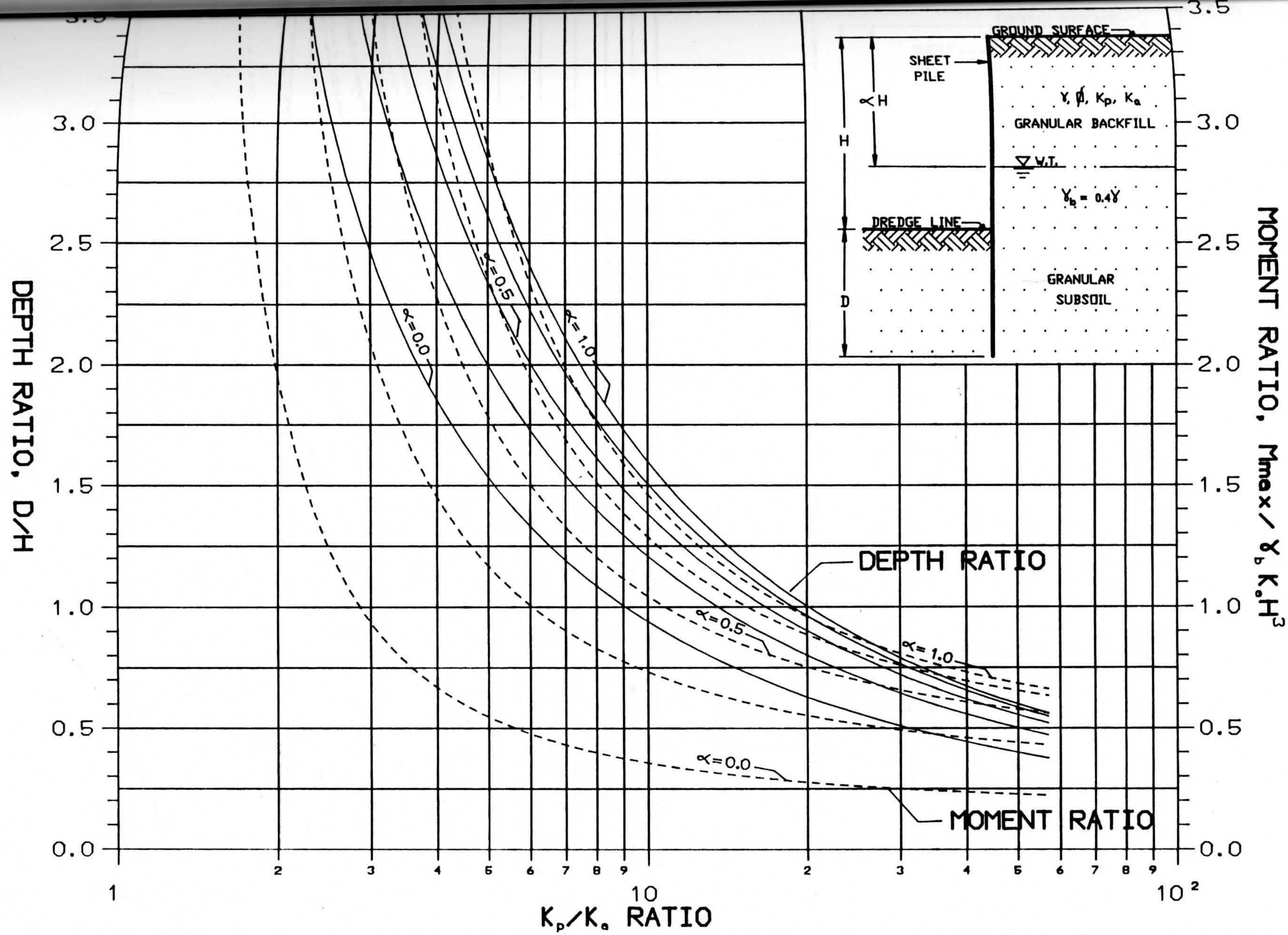


FIGURE 2
CANTILEVER STEEL SHEET PILE
GRANULAR SUBSOIL WITH GRANULAR BACKFILL
$\gamma_b = 0.4\gamma$

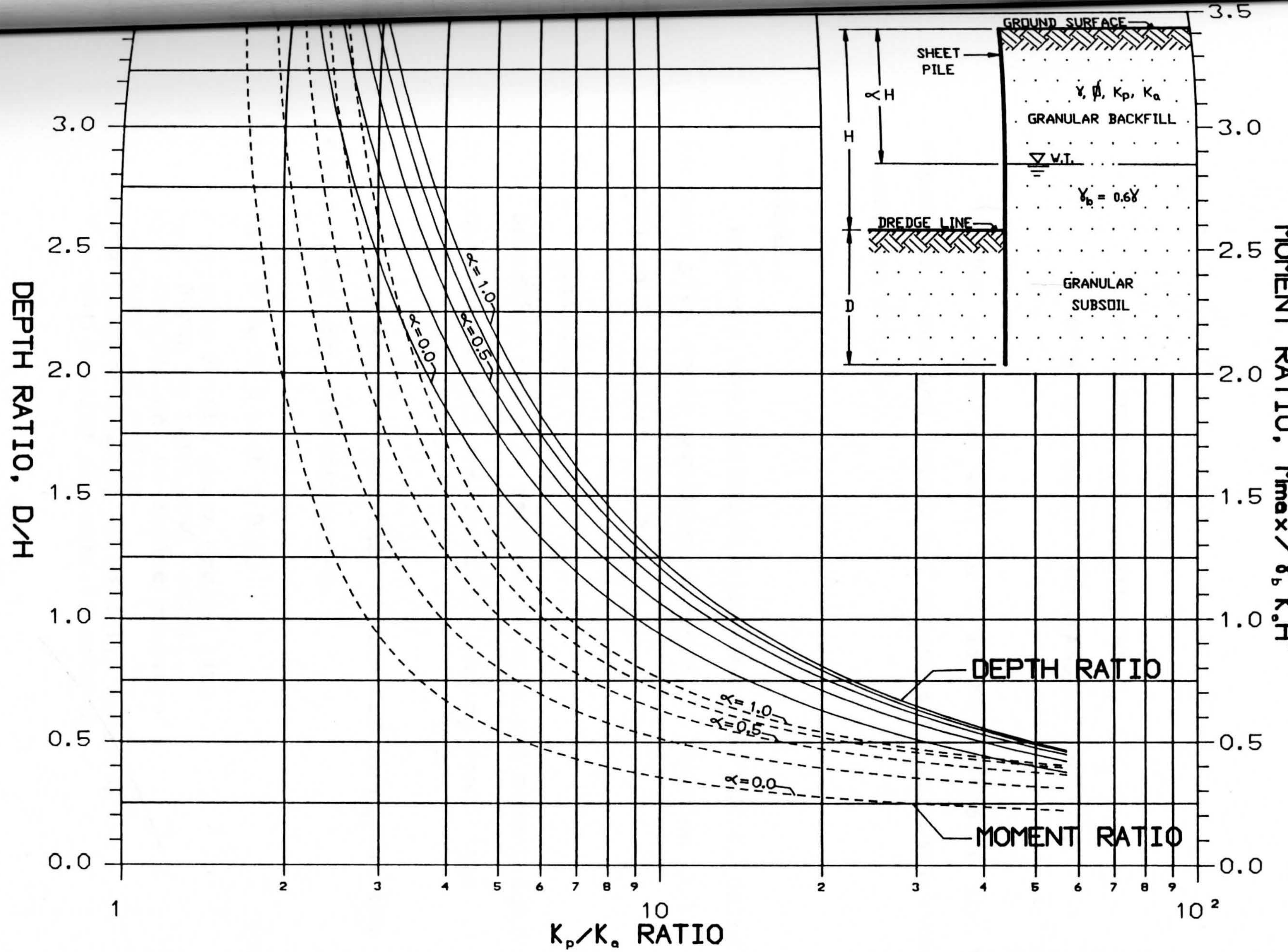


FIGURE 3
CANTILEVER STEEL SHEET PILE
GRANULAR SUBSOIL WITH GRANULAR BACKFILL
$\gamma_b = 0.6\gamma$

CHAPTER 3

CANTILEVER STEEL SHEET PILE, COHESIVE SUBSOIL AND GRANULAR BACKFILL

Two equations will be used to determine the pile embedment depth and moment for cohesive subsoil and backfill loading conditions.

3.1 Case 2

Analysis was performed with program PILE.4, using the minimum pile depth equation derived in Section 3.1.1 and summarized in Section 3.1.2.

3.1.1 Derivations

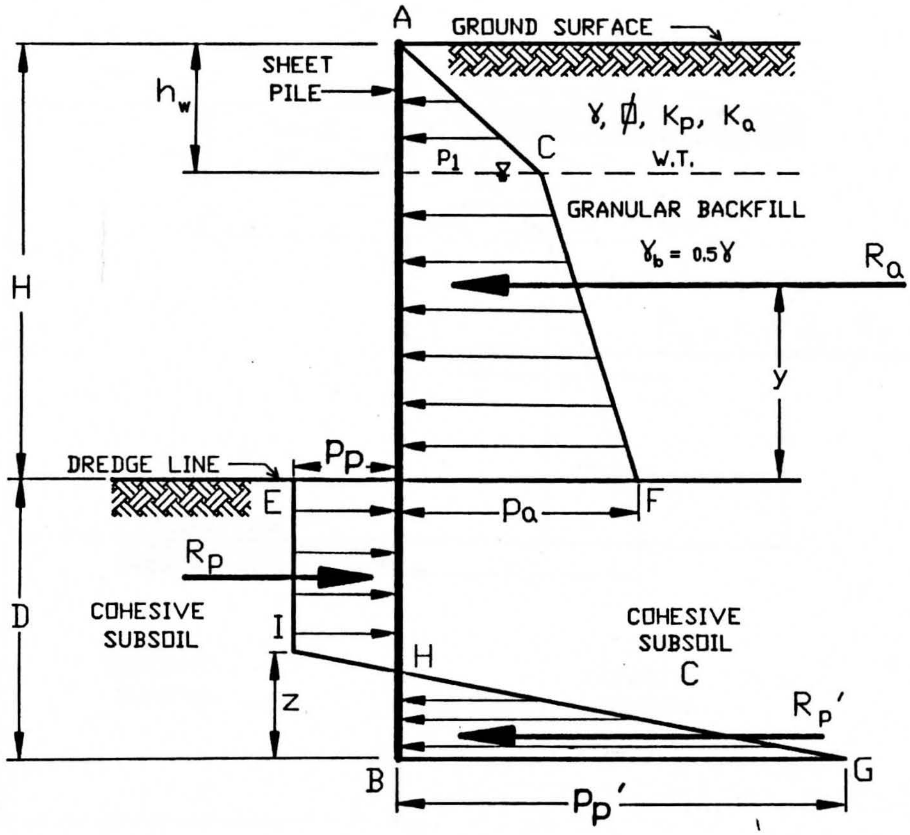
Determine the pile embedment depth and moment equations for cohesive subsoil and backfill loading conditions.

Step 1 Find the unit backfill active force, p_a, at the dredge line shown on Figure 3-1.

$$p_a = K_a \left[\gamma h_w + \gamma_b (H - h_w) \right] \qquad \text{(eq 1)}$$

- H = Pile height above dredge line
- h_w = Depth to saturated backfill
- K_a = Coefficient of active pressure = $\tan^2 (45 - \phi/2)$
- γ_b = Buoyant density of backfill material
- γ = Wet density of backfill material

Figure 3-1



Step 2 Find the active backfill forces from Figure 3-2.

R_a = Resultant of active forces = $R_1 + R_2 + R_3$ (eq 2)

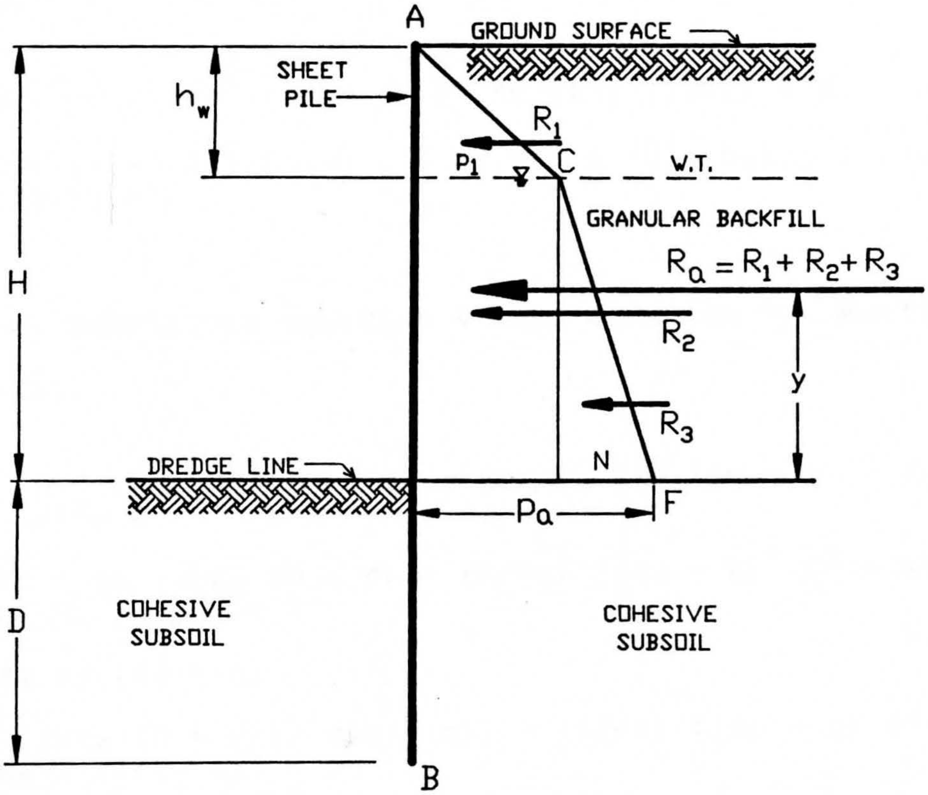
$$R_1 = .5\ \gamma\ h_w^2\ K_a$$
$$R_2 = p_1\ (H - h_w) = \gamma\ h_w\ K_a\ (H - h_w)$$
$$R_3 = .5N\ (H - h_w)$$
$$N = p_a - p_1 = \gamma_b\ K_a\ (H - h_w)$$
$$= .5\ \gamma_b\ K_a\ (H - h_w)^2$$

Step 3 Find the centroid, y, of R_a from Figure 3-2.

y = Distance from centroid of active forces to point of zero shear

$$= [R_1\ (H - .67h_w) + .5R_2\ (H - h_w) + .33R_3\ (H - h_w)]/\ R_a \quad \text{(eq 3)}$$

Figure 3-2



Step 4 Sum forces in the horizontal direction from Figure 3-1.

$$R_a + R_p' - R_p = 0$$

$$R_a + .5z\ (p_p + p_p') - D\ p_p = 0$$

c = Cohesion of subsoil
$q = h_w + \gamma_b\ (H - h_w)$
$p_p = 4c - q$
$p_p' = 4c + q$

$$R_a + .5z\ (4c - q + 4c + q) - D\ (4c - q) = 0$$

$$R_a + .5z\ (8c) - D\ (4c - q) = 0$$

$z = [D\ (4c - q) - Ra]/\ 4c$ (eq 4)

Step 5 Sum moments about the bottom of sheet pile from Figure 3-1.

$$R_a\ (D + y) - .5D^2\ (4c - q) + .5z\ (8c)\ (.33z) = 0 \qquad \text{(eq 5)}$$

$$R_a\ (D + y) - .5D^2\ [4c - (\gamma h_w + \gamma_b\ (H - h_w))] + .5z\ (8c) \times (.33z) = 0 \qquad \text{(eq 6)}$$

Step 6 Substitute equation 4 into equation 5. Multiply by (- 2).

$$-2R_a\ (D + y) + D^2\ (4c - q) - (8c/3)\ [(D\ (4c - q) - R_a] / 4c]^2 = 0$$

$$D^2\ (4c - q) - 2R_a\ (D + y) - (1/6c)\ [(4c - q)^2\ D^2 - 2D\ (4c - q)\ R_a + R_a^2] = 0$$

divide by (4c - q)

$$D^2 - [(2R_a\ (D + y))/\ (4c - q)] - (1/6c)\ [(4c - q)\ D^2 - 2D\ R_a + R_a^2/\ (4c - q)] = 0$$

$$[1 - (4c - q)/\ 6c]\ D^2 + 2R_a\ [(1/6c) - 1/(4c - q)]\ D - [R_a / (4c - q)]\ [(R_a/6c) + 2y] = 0 \qquad \text{(eq 7)}$$

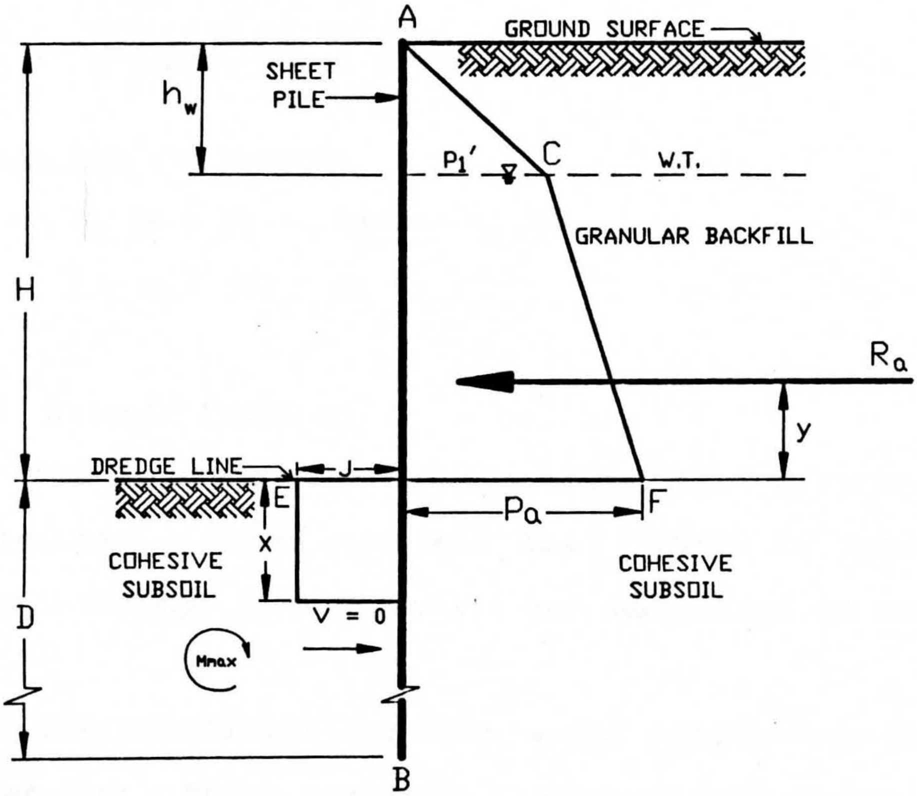
Step 7 Find the maximum moment for the sheet pile from Figure 3-3, which occurs where the shear, v, is equal to zero.

$$M_{max} = R_a\ (y + X) - .5(4c - q)\ X^2 \qquad \text{(eq 8)}$$

where:

$$X = R_a/\ (4c - q)$$

Figure 3-3



3.1.2 Summary of Equations

Minimum Embedment Depth:

$$[(4c - q)/6c - 1]\,D^2 - 2R_a\,[(1/6c) - 1/(4c - q)]\,D + [R_a/(4c - q)]\,[(R_a/6c) + 2y] = 0 \qquad \text{(eq 3-1)}$$

D = Minimum pile embedment depth

H = Pile height above dredge line

h_w = Depth to saturated backfill

K_a = Coefficient of active pressure (eq 2-4)

γ_b = Buoyant density of backfill

γ = Wet density of backfill

R_a = Resultant of active forces = $R_1 + R_2 + R_3$ (eq 3-2)

$R_1 = .5\ \gamma\ h_w^2\ K_a$

$R_2 = \gamma\ h_w\ K_a\ (H - h_w)$

$R_3 = .5\ \gamma_b\ K_a\ (H - h_w)^2$

y = Distance from centroid of active forces to point of zero shear

$= [R_1 (H - .67h_w) + .5R_2 (H - h_w) + .33R_3 \times (H - h_w)] / R_a$ (eq 3-3)

c = Cohesion of subsoil

q = Effective soil pressure at dredge line

$= \gamma h_w + \gamma_b (H - h_w)$ (eq 3-4)

Maximum Bending Moment:

$$Mmax = R_a (y + X) - .5(4c - q) X^2 \quad \text{(eq 3-5)}$$

$$X = R_a / (4c - q) \quad \text{(eq 3-6)}$$

3.1.3 Example Problems

Five problems were solved using PILE.4 program, Option 1 selection. These problems are include in Appendix B, Sheets 7 through 11 and results are summarized in Table 4.

The backfill's friction angle ranged from 30 to 33 degrees for these problems. Minimum pile depth results deviated from the authors' solutions (Bowles 1982 & Das 1983) of 0.0 to 0.3 percent (five solutions) and maximum moment deviated by 0.0 percent (two solutions).

3.1.4 Design Graph ($\gamma_b = .5 \gamma$)

PILE.4 program, Option 4 selection was used to develop Figure 4. Computer computations were in the English system and are included in Appendix E. Six solutions are summarized on Table 4, for α equals 0, 0.5 and 1.0. The backfill's friction angle selected is 28 and 37 degrees from the graph data. At a zero degree backfill slope the cohesion ratio $[(2q_u - q)/ \gamma_b K_a H]$ is 7.67 and 16.18, respectively.

Minimum pile depth ratio (D/H) results deviated from the Teng's graph (USS 1975, Figure 22) by 2.1 to 13.2 percent and maximum moment ratio ($M_{max}/ \gamma_b K_a H^3$) deviated by 0.0 percent. Results are plotted on semi-logarithmic paper on Figure 4 as described in Section 2.1.4.

3.1.5 New Graphs ($\gamma b = .4 \gamma$, $.6 \gamma$)

Two new graphs were developed for various soil conditions and water levels. These include Figures 5 and 6 for a backfill buoyant density of $\gamma b = .4 \gamma$ and $.6 \gamma$, respectively.

TABLE 3
CASE 2 SUMMARY
OPTION 3
CANTILEVER STEEL SHEET PILE
COHESIVE SUBSOIL AND GRANULAR BACKFILL

			FRICTION	MINIMUM EMBEDMENT DEPTH, D			BACKFILL ACTIVE FORCE, R_a			MAXIMUM MOMENT, Mmax		
PROBLEM	REF	SYSTEM	ANGLE	TEXT (1)	PILE.4	DEVIATION	TEXT (1)	PILE.4	DEVIATION	TEXT (1)	PILE.4	DEVIATION
13–2A	1	S.I.	30° (2)	2.72 m	2.73 m	0.0 %	82.6 kN/m	82.7 kN/m	0.0 %	NA	198.8 kN–m/m	--
ex 6.2	2	S.I.	32°	2.13 m	2.14 m	0.0 %	52.2 kN/m	52.2 kN/m	0.0 %	103.6 kN–m/m	103.6 kN–m/m	0.0 %
13–8A	1	English	30° (2)	12.91 ft	12.95 ft	0.3 %	8,300 lbs/ft	8,312 lbs/ft	0.1 %	NA	86,445 ft–lbs/ft	--
13–8D	1	S.I.	33° (2)	1.84 m	1.84 m	0.0 %	113.2 kN/m	113.1 kN/m	0.0 %	NA	314.0 kN–m/m	--
6.7	2	S.I.	30°	7.00 m	7.01 m	0.0 %	NA	99.3 kN/m	--	367.0 kN–m/m	367.2 kN–m/m	0.0 %

Notes:
1. These answers are from the referenced text books.
2. The wall friction is 17 degrees for this problem.

References:

1. Bowles, Joseph E. 1982, Foundation Analysis and Design, 3rd edition.
2. Das, Braja 1983, Advanced Foundation Design.

TABLE 4
CASE 2 SUMMARY
OPTION 4
CANTILEVER STEEL SHEET PILE
COHESIVE SUBSOIL AND GRANULAR BACKFILL

α RATIO	COHESION RATIO	FRICTION ANGLE	DEPTH RATIO			MOMENT RATIO		
			GRAPH (1)	PILE.4	DEVIATION	GRAPH (1)	PILE.4	DEVIATION
0	9.0	30°	0.30	0.34	13.3 %	0.18	0.18	0.0 %
0	1.0	30°	1.50	1.34	−10.6 %	0.29	0.29	0.0 %
0.5	9.0	30°	0.45	0.47	4.4 %	0.35	0.35	0.0 %
0.5	1.0	30°	2.45	2.13	−13.0 %	0.69	0.69	0.0 %
1.0	9.0	30°	0.48	0.49	2.1 %	0.39	0.39	0.0 %
1.0	1.0	30°	2.72	2.36	−13.2 %	0.83	0.83	0.0 %

Notes:
1. α Ratio = γ_b / γ = Buoyant Density/ Wet Density
2. Cohesion Ratio = $(2q_u - q) / \gamma_b K_a H$
3. Depth Ratio = D/ H = Minimum Pile Embedment Depth/ Pile Height Above Dredge Line
   K_a = Coefficient of Active Pressure
   q = Effective Soil Pressure At Dredge Line
   q_u = 2 x Subsoil Cohesion
4. Moment Ratio = $Mmax / \gamma_b K_a H^3$
   Mmax = Maximum Moment

Reference:

1. United States Steel Corporation, Steel Sheet Piling Design Manual, Figure 22.

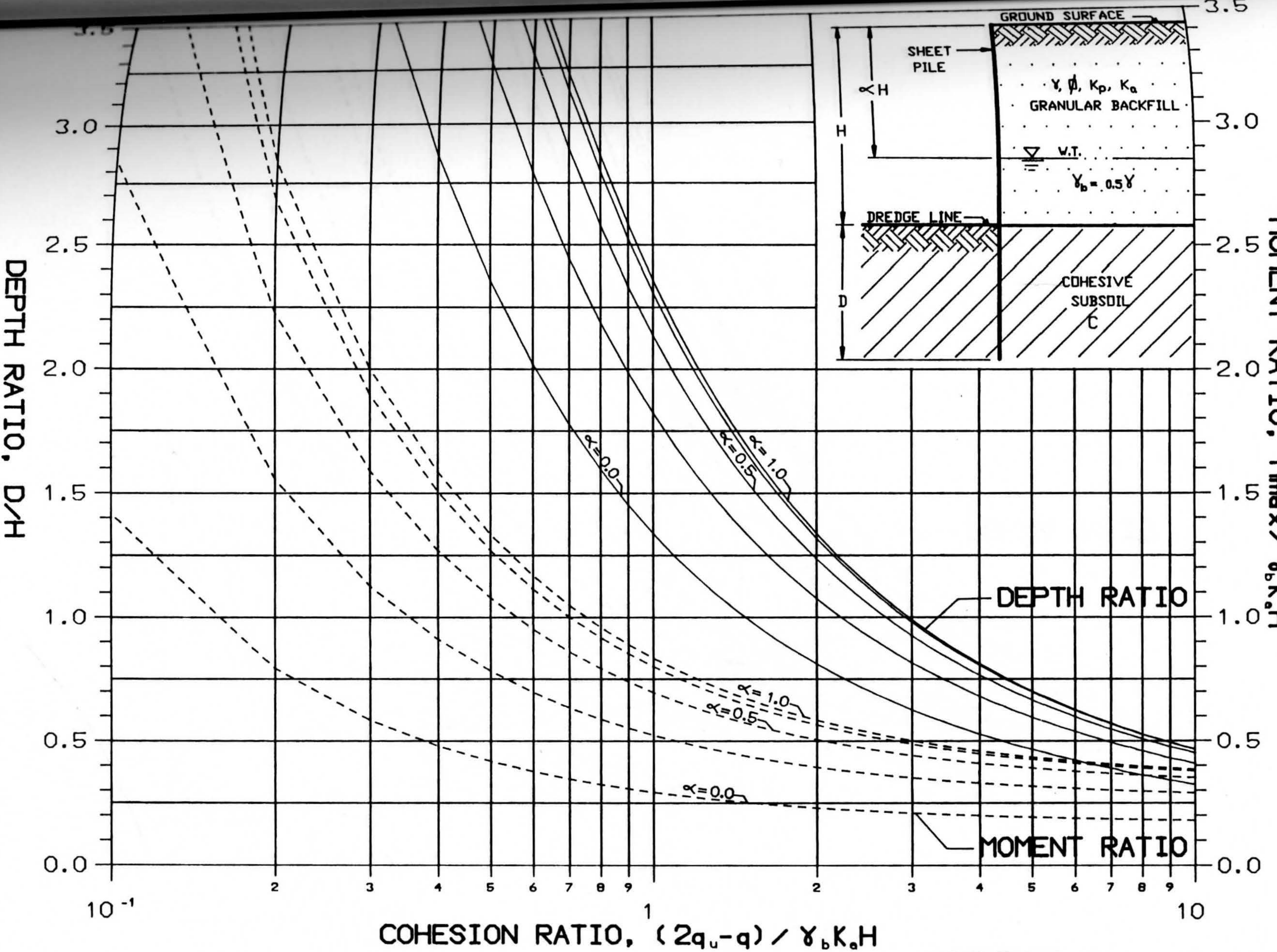


FIGURE 4
CANTILEVER STEEL SHEET PILE
COHESIVE SUBSOIL WITH GRANULAR BACKFILL
$\gamma_b = 0.5\gamma$

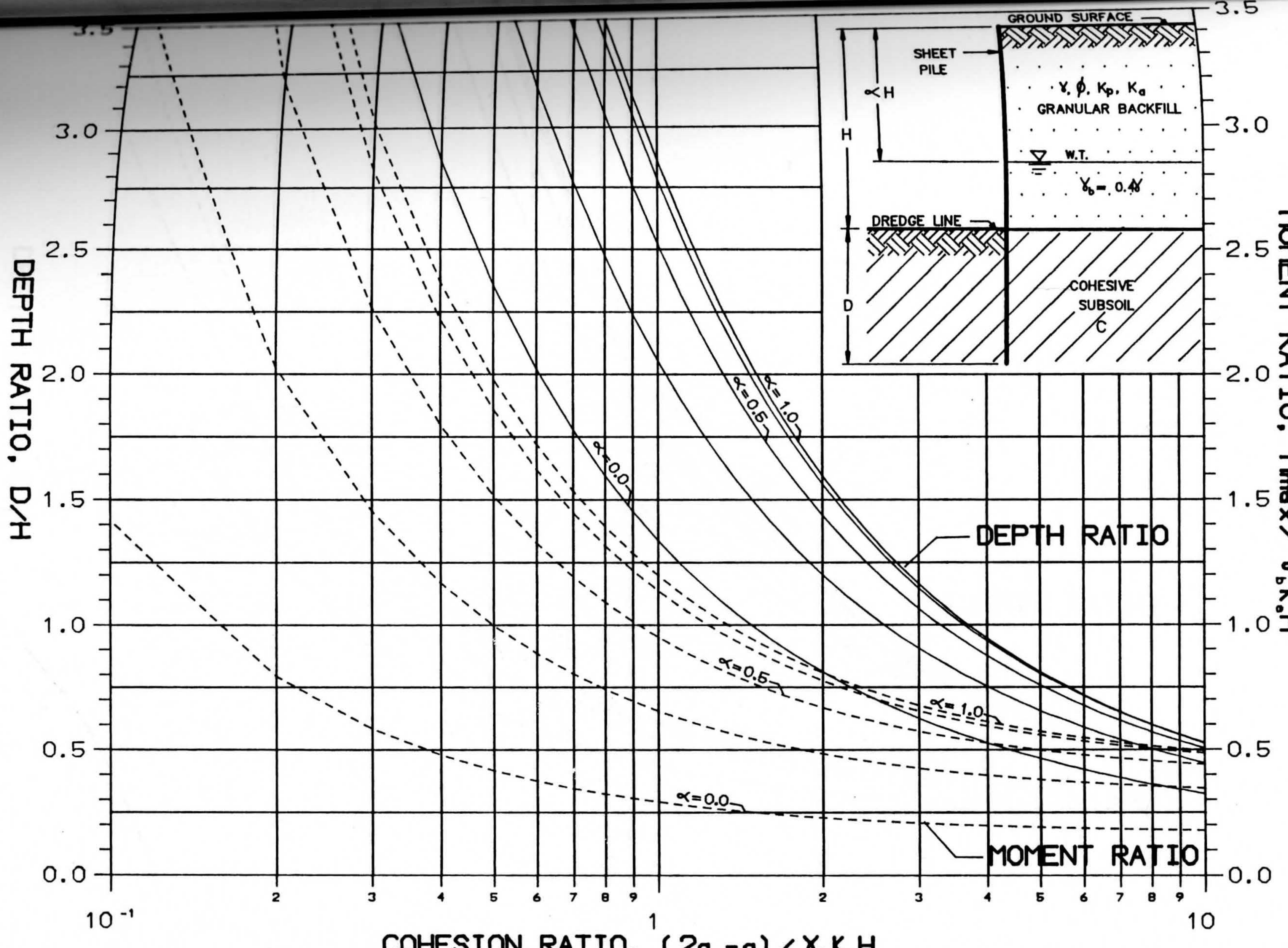


FIGURE 5
CANTILEVER STEEL SHEET PILE
COHESIVE SUBSOIL WITH GRANULAR BACKFILL
$\gamma_b = 0.4\gamma$

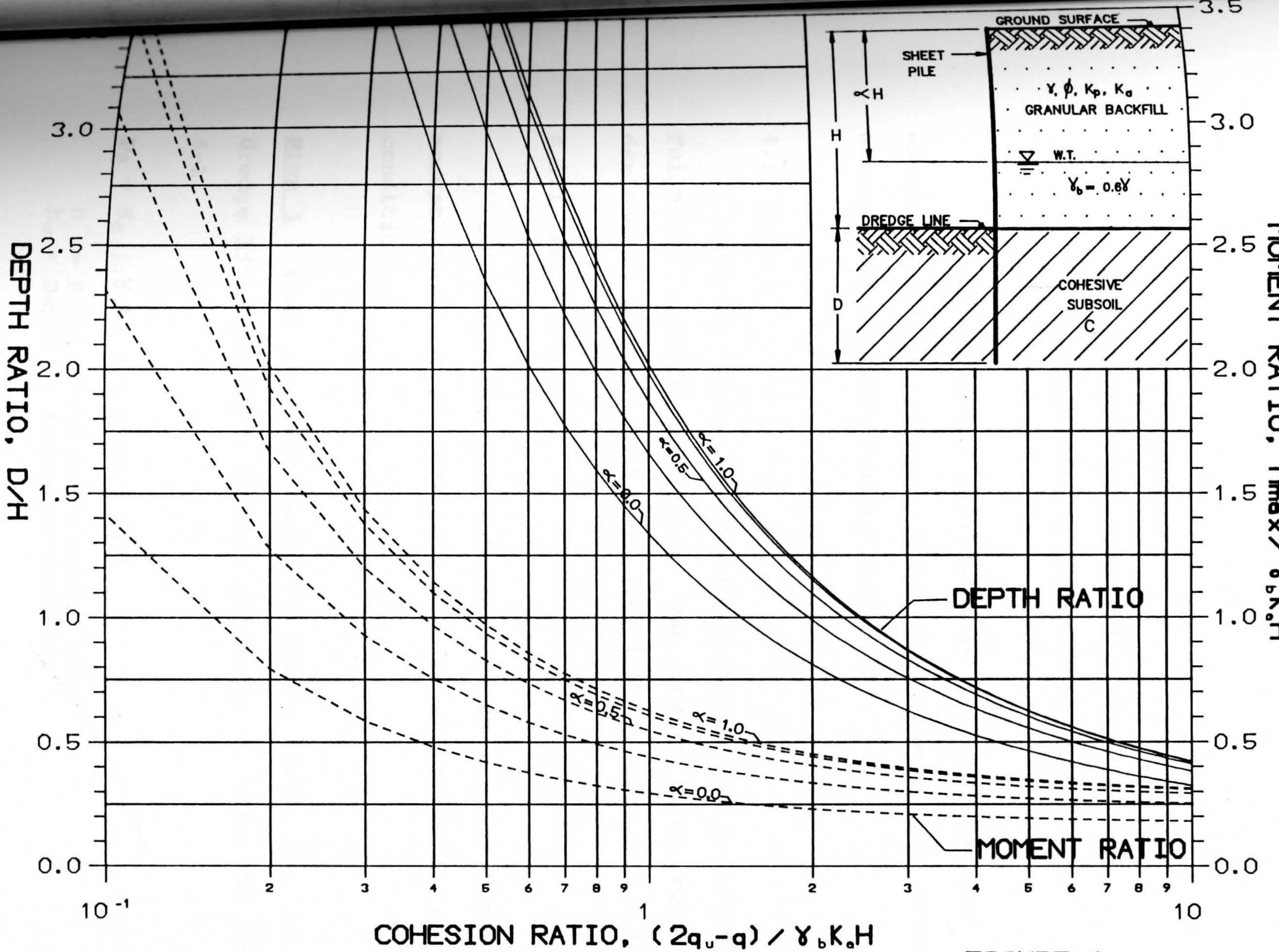


FIGURE 6
CANTILEVER STEEL SHEET PILE
COHESIVE SUBSOIL WITH GRANULAR BACKFILL
$\gamma_b = 0.6\gamma$

CHAPTER 4

ANCHORED STEEL SHEET PILE,

GRANULAR SUBSOIL AND GRANULAR BACKFILL

Three equations will be used to determine the pile embedment depth, anchor force and moment for granular subsoil and backfill loading conditions.

4.1 Case 3

Analysis was performed with program PILE.4, using the following minimum pile depth and anchor force equations derived in Section 4.1.1 and summarized in Section 4.1.2.

4.1.1 Derivations

Determine the pile embedment depth, anchor force and moment equations for granular subsoil and backfill loading conditions.

Step 1 Find the unit backfill active force, p_a, at the dredge line and depth to zero pressure, a, shown on Figure 4-1.

$$p_a = K_a \, [\, \gamma \, h_w + \gamma_b \, (H - h_w)] \qquad \text{(eq 1)}$$

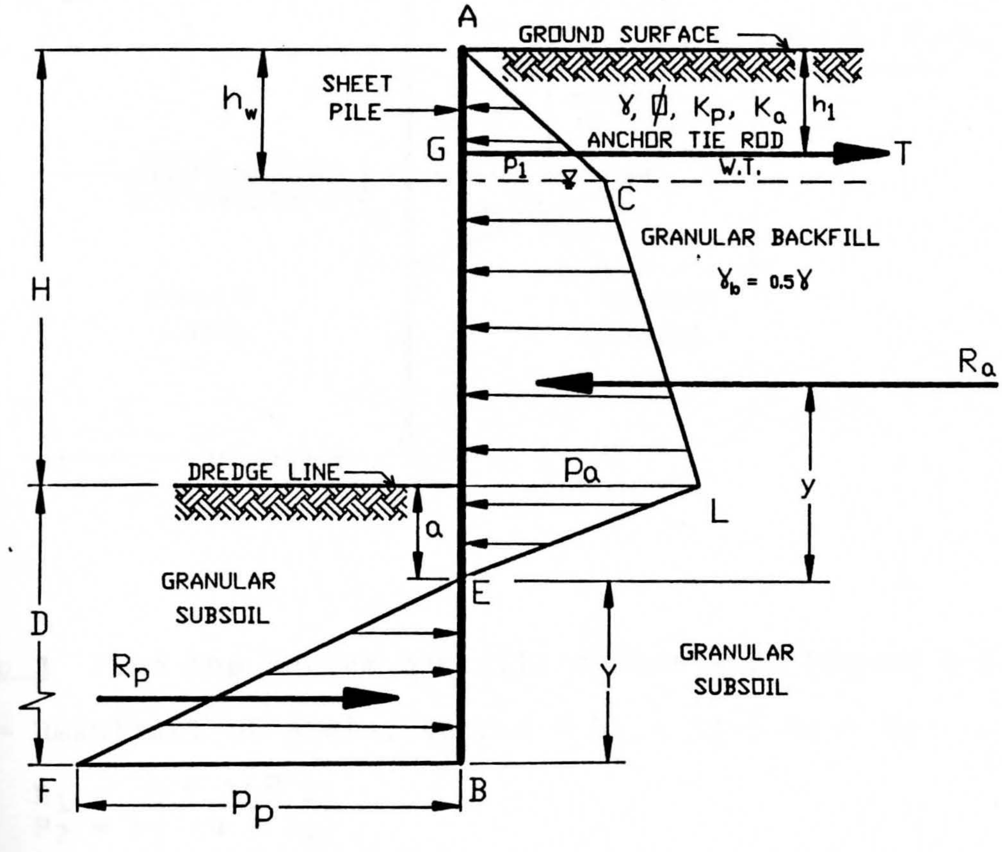
H = Pile height above dredge line
h_w = Depth to saturated backfill

K_a = Coefficient of active pressure
= $\tan^2 (45 - \phi/2)$
γ_b = Buoyant density of backfill material
γ = Wet density of backfill material

$$a = p_a / [\gamma_b (K_p - K_a)] \quad \text{(eq 2)}$$

K_p = Coefficient of passive pressure
= $\tan^2 (45 + \phi/2)$

Figure 4-1



<u>**Step 2**</u> Find the unit subsoil passive force, p_p, at the bottom of the pile shown on Figure 4-1.

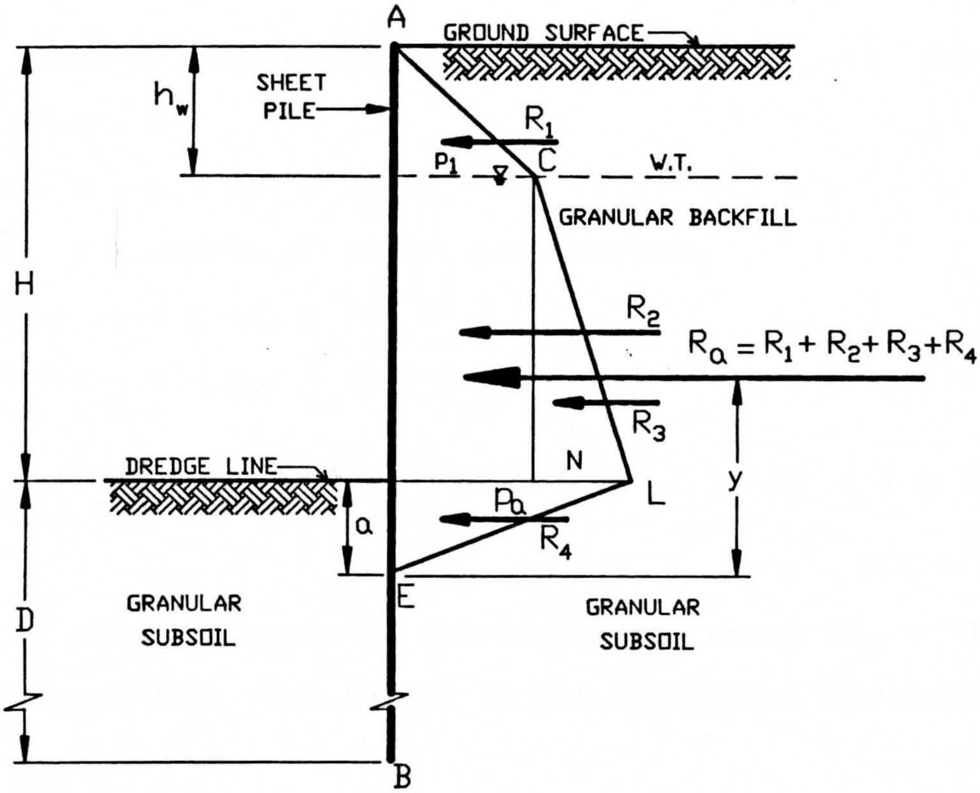
$p_a / a = p_p / Y$

substitute a

$p_a / [p_a / [\gamma_b (K_p - K_a)]] = p_p / Y$

$$p_p = \gamma_b (K_p - K_a) Y \quad \text{(eq 3)}$$

Figure 4-2



Step 3 Find the active backfill forces from Figure 4-2.

R_a = Resultant of active forces = $R_1 + R_2 + R_3 + R_4$ (eq 4)

$$R_1 = .5\,\gamma\, h_w^2\, K_a$$
$$R_2 = p_1\,(H - h_w)$$
$$= \gamma\, h_w\, K_a\,(H - h_w)$$
$$R_3 = .5N\,(H - h_w)$$
$$N = p_a - p_1$$
$$= \gamma_b\, K_a\,(H - h_w)$$
$$= .5\,\gamma_b\, K_a\,(H - h_w)^2$$
$$R_4 = .5p_a\, a$$

Step 4 Find the centroid, y, of R_a from Figure 4-2.

y = Distance from centroid of active forces to point of zero shear

$$y = [R_1 (a + H - .67h_w) + R_2 [a + .5(H - h_w)] + R_3 [a + .33(H - h_w)] + .67R_4 a]/ R_a \qquad \text{(eq 5)}$$

Step 5 Sum moments about point G on the sheet pile shown on Figure 4-1.

$$R_a (H + a - y - h_1) - R_p (H + a + .67Y - h_1) = 0$$

h_1 = Distance of anchor from surface

$R_p = .5 \gamma_b (Kp - Ka) Y^2$

$$R_a (H + a - y - h_1) - .5 \gamma_b (Kp - Ka) Y^2 (H + a + .67Y - h_1) = 0$$

$$Y^3 + 1.5(H + a - h_1) Y^2 - 3R_a (H + a - y - h_1)/ [\gamma_b (K_p - K_a)] = 0 \qquad \text{(eq 6)}$$

Step 6 Find the force in the anchor rod where ($h_w < H$) from Figure 4-1. Sum forces in the horizontal direction.

$$R_a - T - R_p = 0$$

$$T = R_a - .5 \gamma_b (K_p - K_a) Y^2 \qquad \text{(eq 7)}$$

Step 7 Sum forces in the horizontal direction for the sheet pile where ($h_w < H$) from Figure 4-3.

$$5p_1 h_w - T + p_1 (z - h_w) + .5N' (z - h_w) = 0 \qquad \text{(eq 8)}$$

$p_1 = \gamma h_w K_a$

$N' = p_a' - p_1$

$= \gamma_b (z - h_w)$

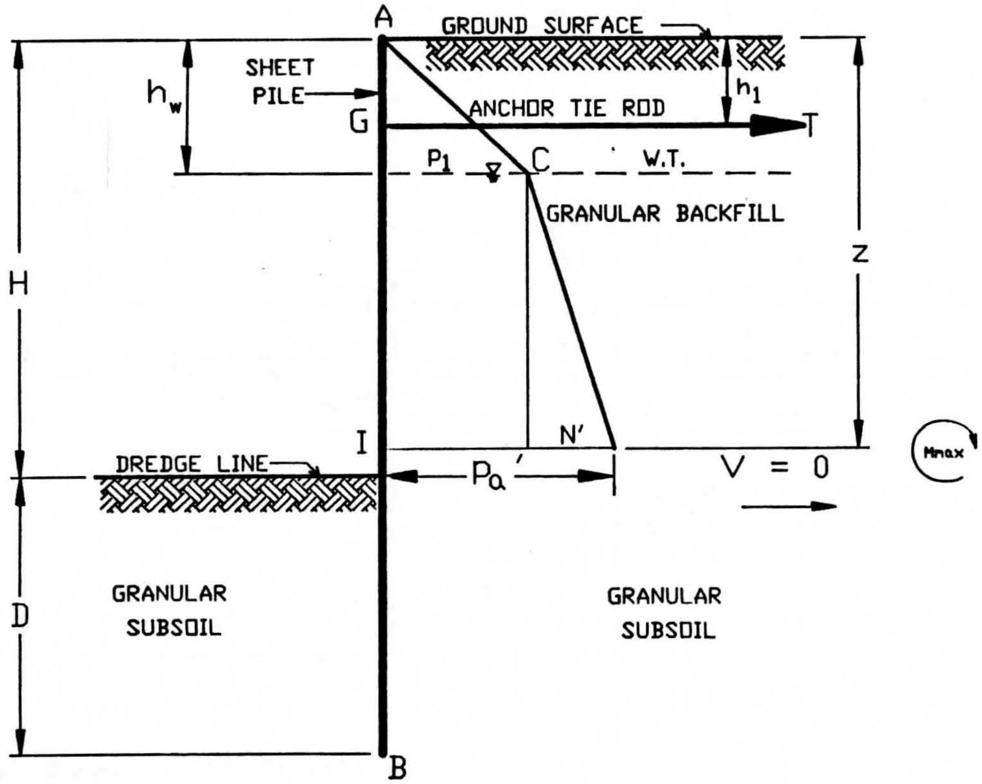
Step 8 Find the maximum moment for the sheet pile where (hw < H) from Figure 4-3, which occurs where the shear, v, is equal to zero.

$$Mmax = T (z - h_1) - .5p_1 h_w (z - .67h_w) - .5p_1 (z - h_w)(z - h_w) - N' [(z - h_w)/ 2] [(z - h_w)/ 3]$$

$$Mmax = T\ (z - h_1) - .5\ \gamma\ h_w^2\ K_a\ (z_3 - .67h_w) - .5\ \gamma\ h_w\ K_a\ (z - h_w)^2 - \gamma_b\ K_a\ (z - h_w)^3 / 6$$

(eq 9)

Figure 4-3



Step 9 Sum forces in the horizontal direction for the sheet pile where (h_w = H) from Figure 4-4.

$5p_1'\ z - T = 0$

$p_1' = \gamma\ z\ K_a$

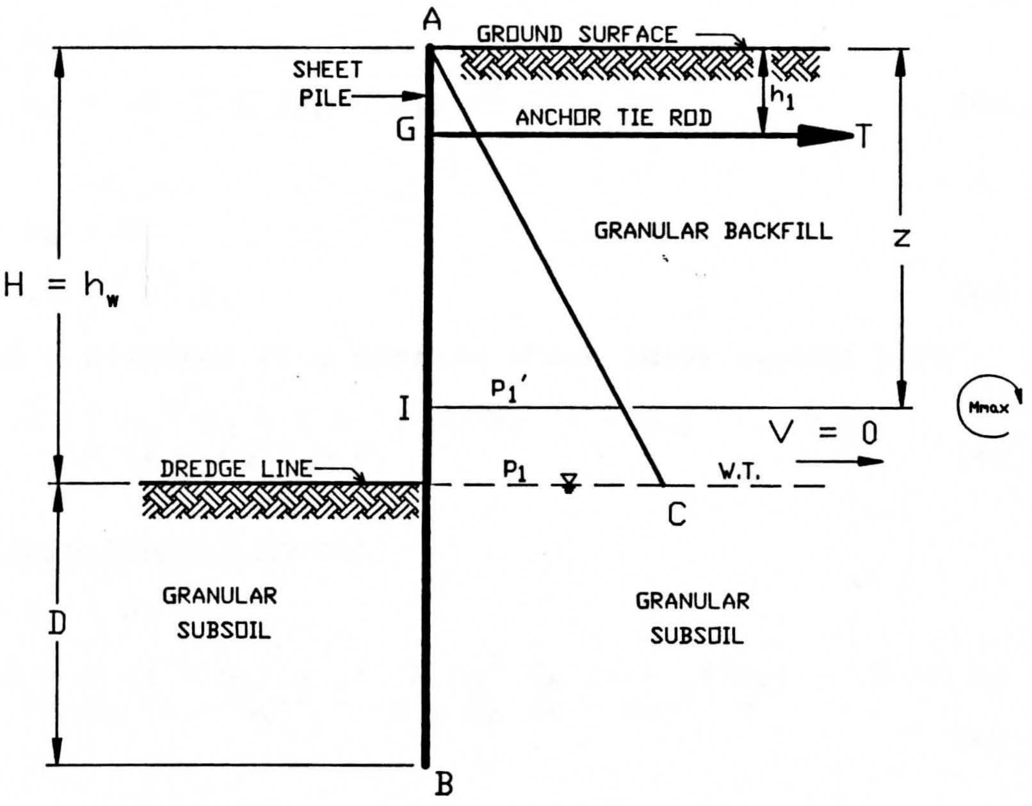
$$T = .5\ \gamma\ z^2\ K_a \qquad \text{(eq 10)}$$

Step 10 Find the maximum moment for the sheet pile where (hw = H) from Figure 4-4, which occurs where the shear, v, is equal to zero.

$Mmax = T\ (z - h_1) - .5\ \gamma\ z^2\ K_a\ (z/3)$

$$Mmax = T\ (z - h_1) - \gamma\ z^3\ K_a / 6 \qquad \text{(eq 11)}$$

Figure 4-4



4.1.2 Summary of Equations

Minimum Embedment Depth:

$$Y^3 + 1.5(H + a - h_1)\ Y^2 - 3R_a(H + a - y - h_1) / [\ \gamma_b\ (K_p - K_a)] = 0 \qquad \text{(eq 4-1)}$$

Y	=	Distance from bottom of pile to point of zero shear, $Y = D - a$	(eq 2-2)
D	=	Minimum pile embedment depth	
H	=	Pile height above dredge line	
h_1	=	Distance of anchor from surface	
h_w	=	Depth to saturated backfill	
K_p	=	Coefficient of passive pressure	(eq 2-3)
K_a	=	Coefficient of active pressure	(eq 2-4)
γ_b	=	Buoyant density of backfill	
γ	=	Wet density of backfill	
a	=	Depth to zero pressure	(eq 2-5)
p_a	=	Unit backfill active force	(eq 2-6)
R_a	=	Resultant of active forces	(eq 2-7)
y	=	Distance from centroid of active forces to point of zero shear	(eq 2-8)

Anchor Pull Force:

For $h_w < H$:

$$T = R_a - .5 \gamma_b (K_p - K_a) Y^2 \qquad \text{(eq 4-2)}$$

For $h_w = H$:

$$T = .5 \gamma z^2 K_a \qquad \text{(eq 4-3)}$$

z = Distance from surface where shear equals zero

$$.5 \gamma h_w^2 K_a - T + \gamma h_w K_a (z - h_w) + .5 \gamma_b \times (z - h_w)^2 = 0 \qquad \text{(eq 4-4)}$$

Maximum Bending Moment:

For $h_w < H$:

$$Mmax = T (z - h_1) - .5 \gamma h_w^2 K_a (z - .67h_w) - .5 \gamma h_w \times K_a (z - h_w)^2 - \gamma_b K_a (z - h_w)^3 / 6 \qquad \text{(eq 4-5)}$$

For $h_w = H$:

$$Mmax = T (z - h_1) - \gamma z^3 K_a / 6 \qquad \text{(eq 4-6)}$$

4.1.3 Example Problems

Three problems were solved using PILE.4 program, Option 5 selection. These problems are included in Appendix B, Sheets 12 through 16 and are summarized on Table 5.

The backfill's friction angle ranged from 30 to 32 degrees for these problems. Minimum pile depth results deviated from the authors' solution (Bowles 1982 & Das 1983) by 0.0 percent (three solutions), anchor pull force deviated by 1.6 to 5 percent and maximum moment by 9.8 percent (one solution).

4.1.4 Design Graph ($\gamma_b = .5\gamma$)

PILE.4 program, Option 6 selection was used to develop Figure 7. Computer computations were calculated in the English system and are included in Appendix E. Six solutions are summarized on Table 6, for α equals 0, 0.5 and 1.0. The backfill's friction angle selected is 28 and 37 degrees from the graph data. At a zero degree backfill slope the K_p/K_a ratios are 7.67 and 16.18, respectively.

Minimum pile depth ratio (D/H) results deviated from Teng's graph (USS 1975, Figure 24) by 0.0 percent, minimum anchor pull ratio ($T/\gamma_b K_a H^2$) deviated 0.0 percent and maximum moment ratio ($Mmax/\gamma_b K_a H^3$) deviated by 0.0 percent. Data results are plotted on semi-logarithmic paper on Figure 7 as described in Section 2.1.4.

4.1.5 New Graphs ($\gamma b = .4\gamma$, $.6\gamma$)

Two new graphs were developed for various soil conditions and water levels. These include Figures 8 and 9 for a backfill buoyant density of $\gamma b = .4\gamma$ and $.6\gamma$, respectively.

TABLE 5
CASE 3 SUMMARY
OPTION 5
ANCHORED STEEL SHEET PILE
GRANULAR SUBSOIL AND GRANULAR BACKFILL

			FRICTION	MINIMUM EMBEDMENT DEPTH, D			BACKFILL ACTIVE FORCE, R_a			MAXIMUM MOMENT, Mmax			ANCHOR PULL FORCE, T		
PROBLEM	REF	SYSTEM	ANGLE	TEXT (1)	PILE.4	DEVIATION	TEXT (1)	PILE.4	DEVIATION	TEXT (1)	PILE.4	DEVIATION	TEXT (1)	PILE.4	DEVIATION
13-3	1	English	30° (2)	8.5 ft	8.5 ft	0.0 %	16,600 lbs/ft	16,600 lbs/ft	0.0 %	NA	109,666 ft-lb/ft	--	9,100 lbs/ft	8,910 lbs/ft	-2.1 %
ex 6.3	2	S.I.	32°	2.06 m	2.02 m	0.0 %	58.32 kN/m	58.35 kN/m	0.0 %	43.32 kN-m/m	48.03 kN-m/m	-9.8 %	30.86 kN/m	32.4 kN/m	5.0 %
6.11	2	S.I.	30°	4.1 m	4.05 m	0.0 %	NA	204.9 kN/m	--	NA	338.5 kN-m/m	--	114.9 kN/m	113.0 kN/m	-1.6 %

Notes:
1. These answers are from the referenced text books.
2. The wall friction is 20 degrees for this problem.

References:

1. Bowles, Joseph E. 1982, Foundation Analysis and Design, 3rd edition.
2. Das, Braja 1983, Advanced Foundation Design.

TABLE 6
CASE 3 SUMMARY
OPTION 6
ANCHORED STEEL SHEET PILE
GRANULAR SUBSOIL AND GRANULAR BACKFILL

α RATIO	K_p/K_a RATIO	FRICTION ANGLE	DEPTH RATIO			MOMENT RATIO			ANCHOR PULL RATIO		
			GRAPH (1)	PILE.4	DEVIATION	GRAPH (1)	PILE.4	DEVIATION	GRAPH (1)	PILE.4	DEVIATION
0	7.67	28°	0.42	0.42	0.0 %	0.09	0.09	0.0 %	0.33	0.33	0.0 %
0	16.18	37°	0.25	0.25	0.0 %	0.07	0.07	0.0 %	0.28	0.28	0.0 %
0.5	7.67	28°	0.57	0.57	0.0 %	0.19	0.19	0.0 %	0.64	0.64	0.0 %
0.5	16.18	37°	0.33	0.33	0.0 %	0.13	0.13	0.0 %	0.54	0.54	0.0 %
1.0	7.67	28°	0.69	0.69	0.0 %	0.27	0.27	0.0 %	0.79	0.79	0.0 %
1.0	16.18	37°	0.39	0.39	0.0 %	0.18	0.18	0.0 %	0.63	0.63	0.0 %

Notes:
1. α Ratio = γ_b/γ = Buoyant Density/ Wet Density
2. K_p/K_a Ratio = Passive Coefficient/ Active Coefficient
3. Depth Ratio = D/ H = Minimum Pile Embedment Depth/ Pile Height Above Dredge Line
4. Moment Ratio = Mmax/ $\gamma_b K_a H^3$
   Mmax = Maximum Moment
5. Anchor Pull Ratio = T/ $\gamma_b K_a H^2$

Reference:

1. United States Steel Corporation July 1975, Steel Sheet Piling Design Manual, Figure 24.

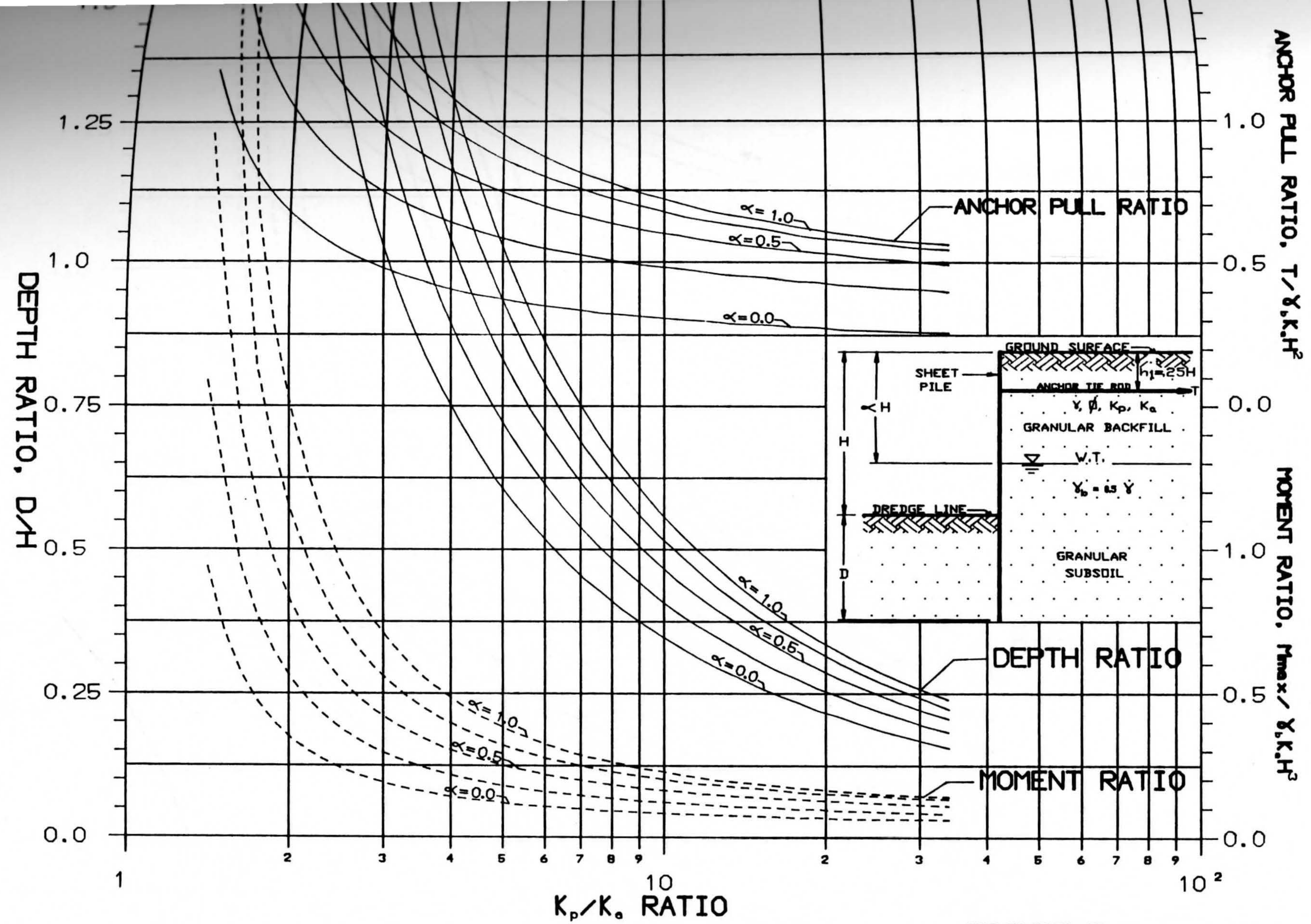


FIGURE 7
ANCHOR STEEL SHEET PILE
GRANULAR SUBSOIL WITH GRANULAR BACKFILL
$\gamma_b = 0.5\gamma$

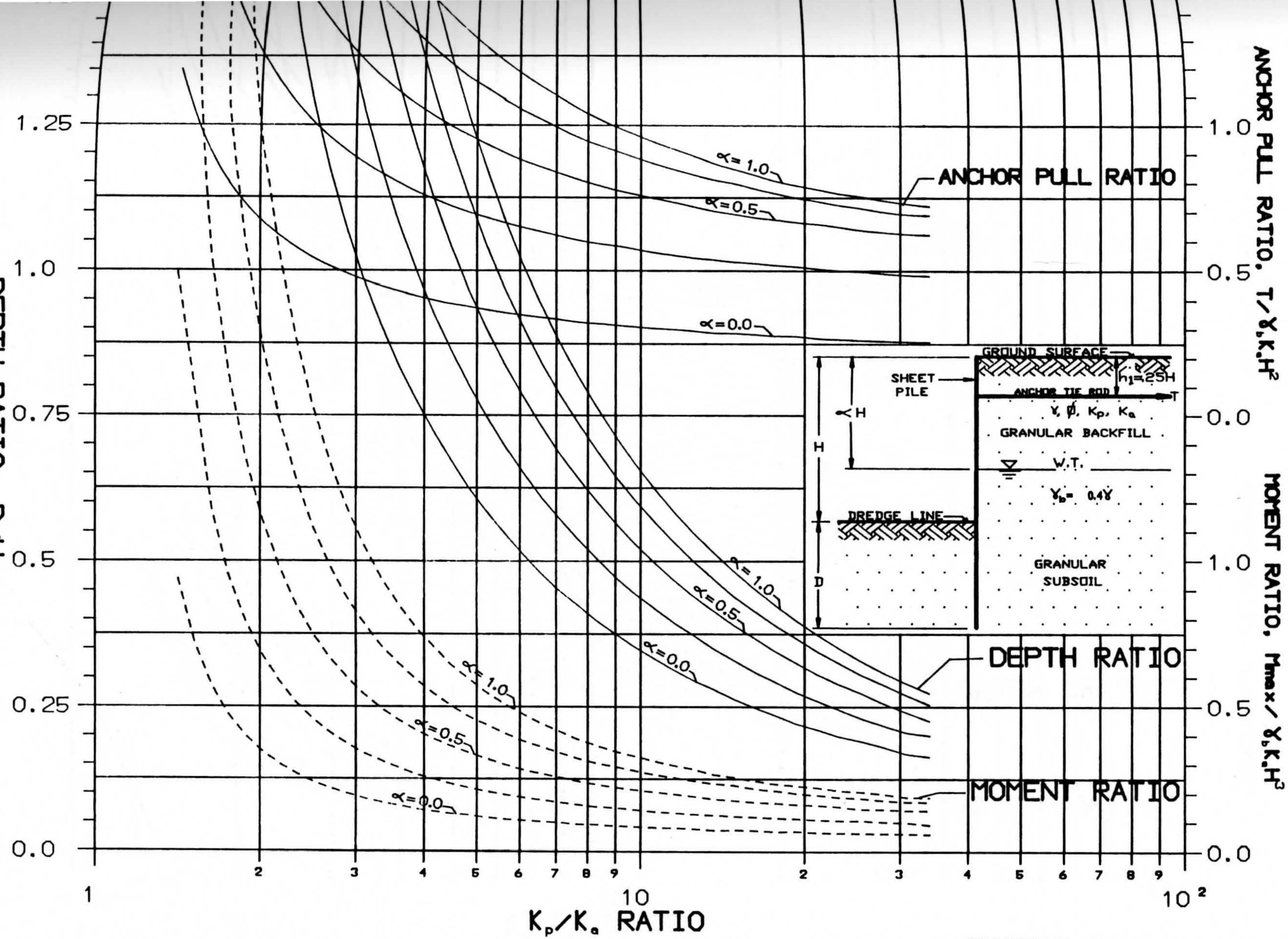


FIGURE 8
ANCHOR STEEL SHEET PILE
GRANULAR SUBSOIL WITH GRANULAR BACKFILL
$\gamma_b = 0.4\gamma$

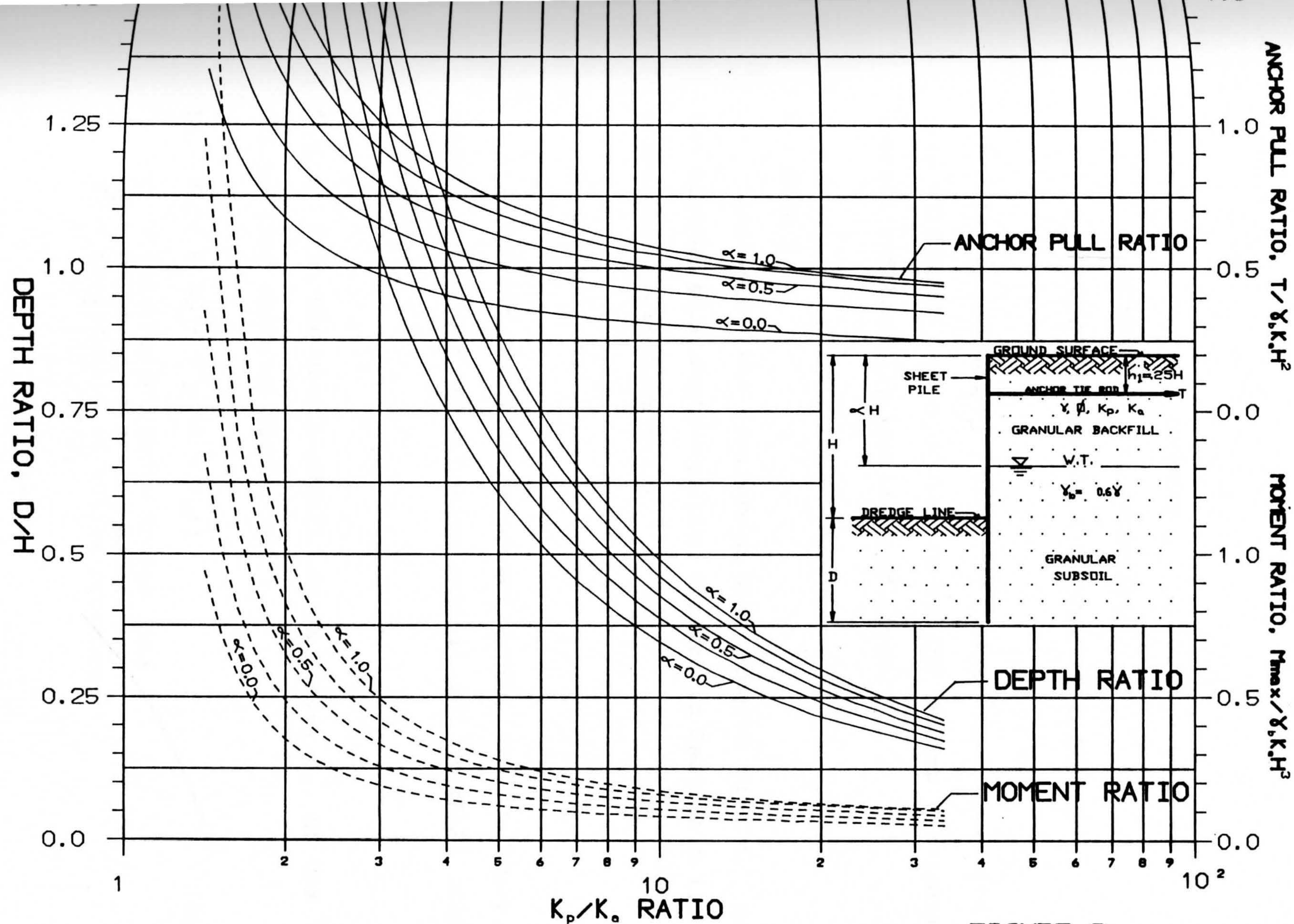


FIGURE 9
ANCHOR STEEL SHEET PILE
GRANULAR SUBSOIL WITH GRANULAR BACKFILL
$\gamma_b = 0.6\gamma$

CHAPTER 5

ANCHORED STEEL SHEET PILE,

COHESIVE SUBSOIL AND GRANULAR BACKFILL

Three equations will be used to determine the pile embedment depth, anchor force and moment for cohesive subsoil and backfill loading conditions.

5.1 Case 4

Analysis was performed with program PILE.4, using the minimum pile depth equation derived in Section 5.1.1 and summarized in Section 5.1.2

5.1.1 Derivations

Determine the pile embedment depth, anchor force and moment equations for cohesive subsoil and backfill loading conditions.

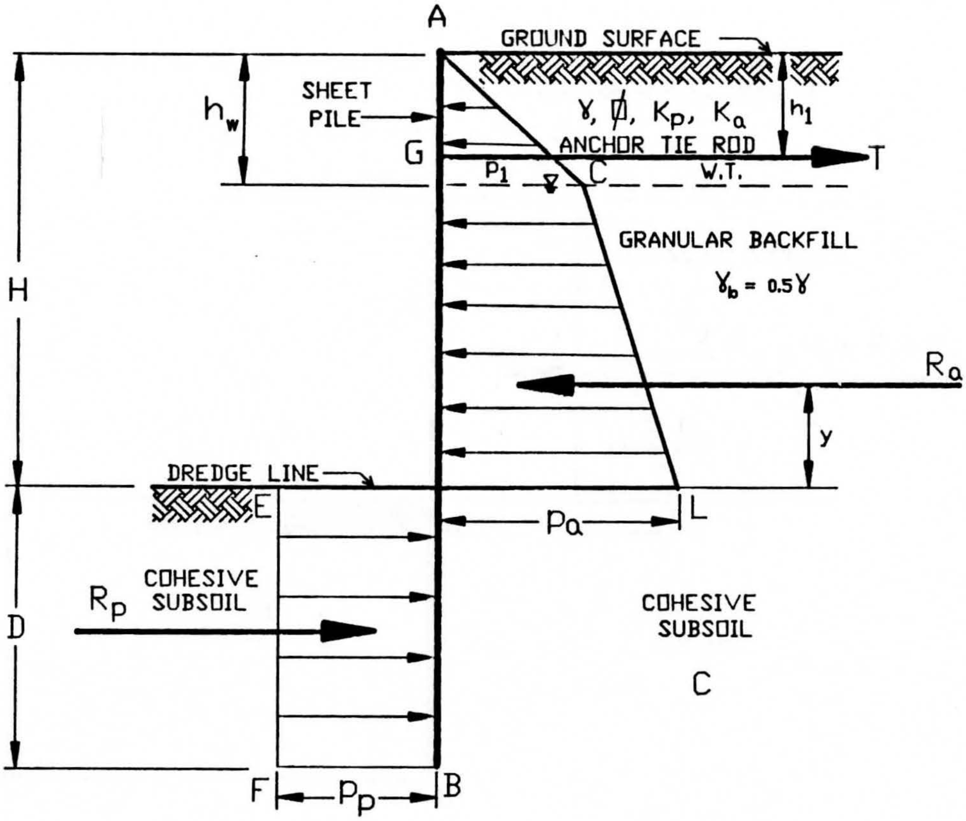
Step 1 Find the unit backfill active force, p_a, at the dredge line shown on Figure 5-1.

$$p_a = K_a [\, \gamma\, h_w + \gamma_b\, (H - h_w)] \qquad \text{(eq 1)}$$

H = Pile height above dredge line
h_w = Depth to saturated backfill
K_a = Coefficient of active pressure
= $\tan^2 (45 - \phi/2)$

γ_b = Buoyant density of backfill material
γ = Wet density of backfill material

Figure 5-1



Step 2 Find the active backfill forces from Figure 5-2.

R_a = Result of active forces = $R_1 + R_2 + R_3$ (eq 2)

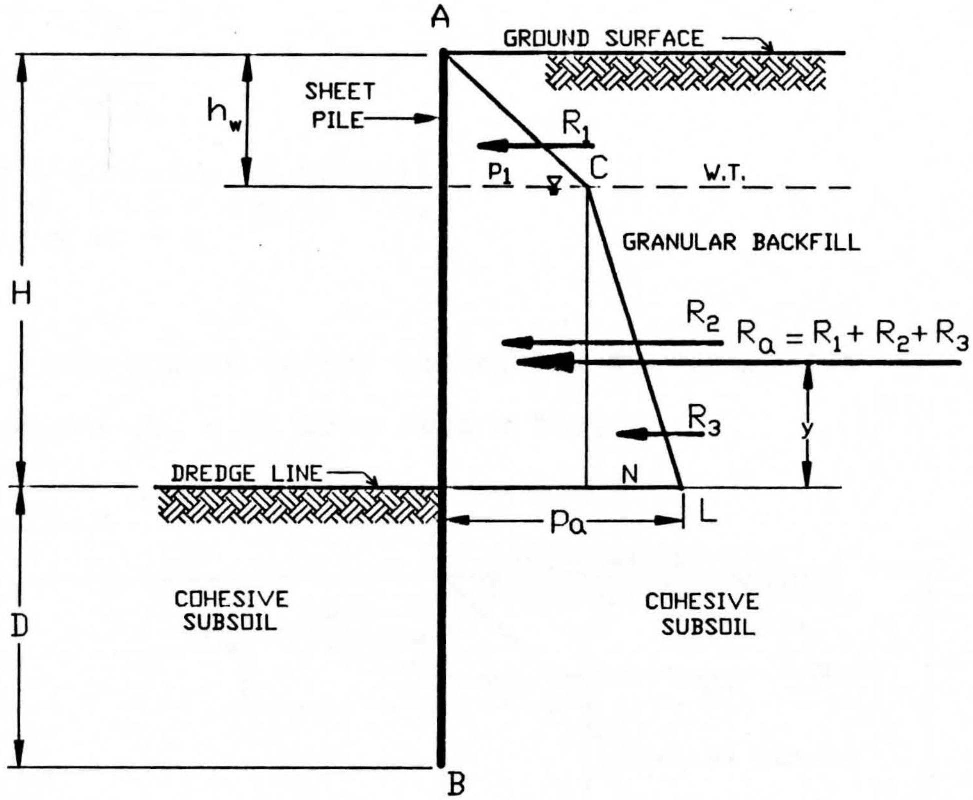
$$
\begin{aligned}
R_1 &= .5\ \gamma\ h_w^2\ K_a \\
R_2 &= p_1\ (H - h_w) \\
&= \gamma\ h_w\ K_a\ (H - h_w) \\
R_3 &= .5N\ (H - h_w) \\
N &= p_a - p_1 \\
&= \gamma_b\ K_a\ (H - h_w) \\
&= .5\ \gamma_b\ K_a\ (H - h_w)^2
\end{aligned}
$$

Step 3 Find the centroid, y, of R_a from Figure 5-2.

y = Distance from centroid of active forces to point of zero shear

$$y = [R_1 (H - .67h_w) + .5R_2 (H - h_w) + .33R_3 (H - h_w)]/ R_a \quad \text{(eq 3)}$$

Figure 5-2



Step 4 Sum moments about point G on the sheet pile shown on Figure 5-1.

$$R_a (H - y - h_1) - R_p (.5D + H - h_1) = 0$$

h_1 = Distance of anchor from surface

$R_p = D\ p_p$

$$R_a (H - y - h_1) - (D\ p_p) (.5D + H - h_1) = 0$$

$$R_a (H - y - h_1) - .5D^2\ p_p - D\ p_p (H - h_1) = 0$$

$$D^2 + 2(H - h_1) D - 2R_a (H - y - h_1)/ p_p = 0 \quad \text{(eq 4)}$$

Step 5 Find the force in the anchor rod where (h_w < H) from Figure 5-1. Sum forces in the horizontal direction.

$$R_a - T - R_p = 0 \qquad \text{(eq 5)}$$

$$T = R_a - R_p$$
$$= R_a - D\ p_p$$

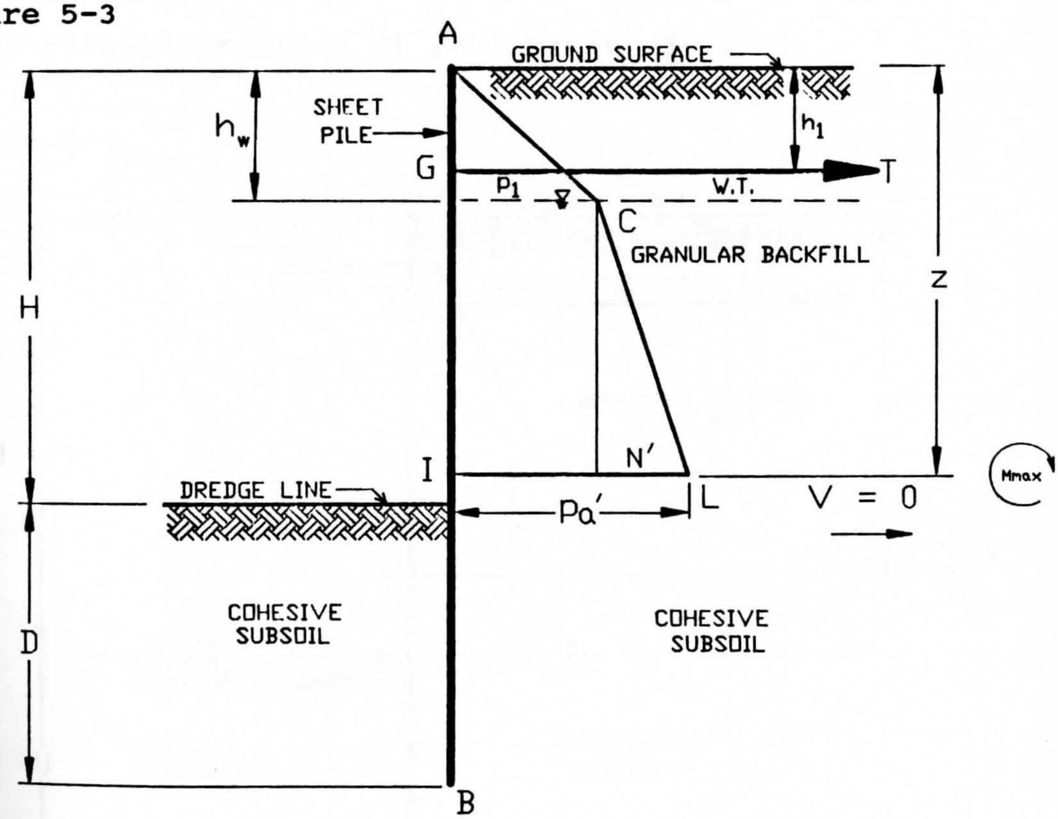
c = Cohesion of subsoil

$q = \gamma\ h_w + \gamma_b\ (H - h_w)$

$p_p = 4c - q$

Step 6 Sum forces in the horizontal direction for the sheet pile where (h_w < H) from Figure 5-3.

Figure 5-3



$$.5p_1\ h_w - T + p_1\ (z - h_w) + .5N'\ (z - h_w) = 0 \qquad \text{(eq 6)}$$

$$p_1 = \gamma\ h_w\ K_a$$

$$p_a = K_a\,[\,\gamma\, h_w + \gamma_b\,(z - h_w)]$$
$$N' = p_a' - p_1$$
$$= \gamma_b\,(z - h_w)$$

Step 7 Find the maximum moment for the sheet pile where (hw < H) from Figure 5-3, which occurs where the shear, v, is equal to zero.

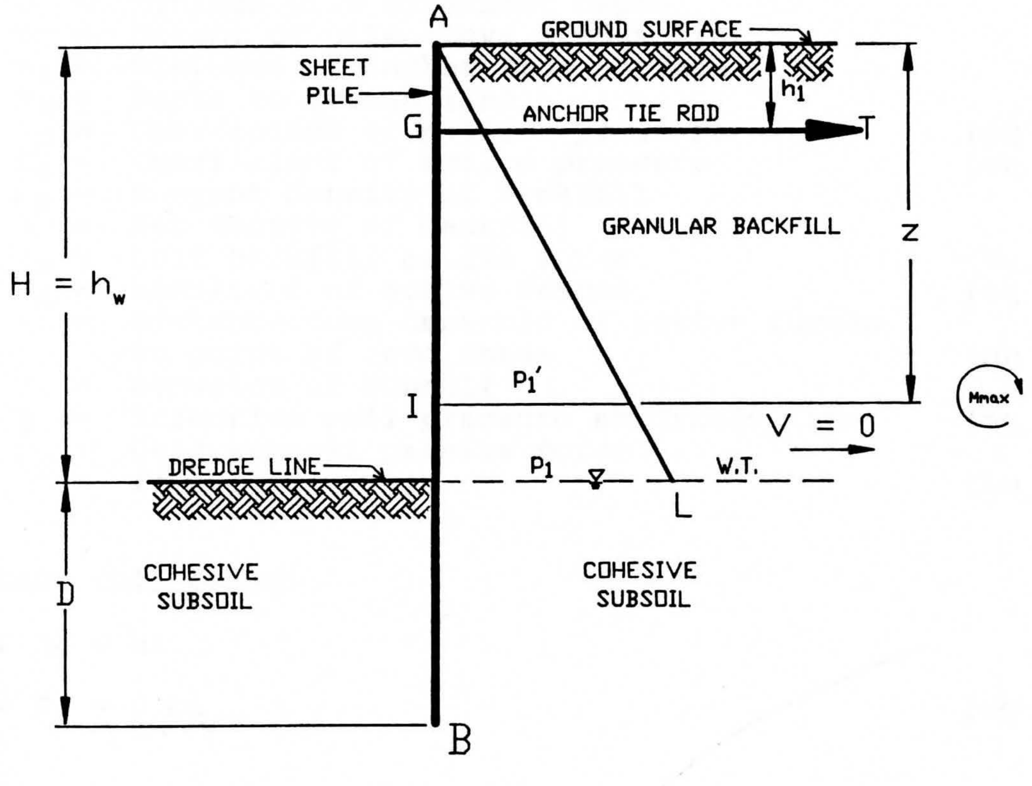
$$M_{max} = T\,(z - h_1) - .5p_1\, h_w\,(z - .67h_w) - .5p_1\,(z - h_w)^2 - N'\,[(z - .67h_w)/\,2]\,[(z - .67h_w)/\,3]$$

$$M_{max} = T\,(z - h_1) - .5\,\gamma\, h_w^2\, K_a\,(z - .67h_w) - .5\, h_w\, K_a\,(z - h_w)^2 - \gamma_b\, K_a\,(z - h_w)^3/\,6]$$

(eq 7)

Step 8 Sum forces in the horizontal direction for the sheet pile where (h_w = H) from Figure 5-4.

Figure 5-4



$.5 p_1' z - T = 0$

$p_1' = \gamma z K_a$

$T = .5 \gamma z^2 K_a$ (eq 8)

Step 9 Find the maximum moment for the sheet pile where (hw = H) from Figure 5-3, which occurs where the shear, v, is equal to zero.

$Mmax = T (z - h_1) - .5 \gamma z^2 K_a (z/3)$

$Mmax = T (z - h_1) - \gamma z^3 K_a / 6$ (eq 9)

5.1.2 Summary of Equations

Minimum Embedment Depth:

$D^2 + 2(H - h_1) D - 2R_a (H - y - h_1)/ p_p = 0$ (eq 5-1)

D	=	Minimum pile embedment depth	
H	=	Height of pile above dredge line	
h_1	=	Distance of anchor from surface	
h_w	=	Depth to dredge line	
K_p	=	Coefficient of passive pressure	(eq 2-3)
K_a	=	Coefficient of active pressure	(eq 2-4)
γ_b	=	Buoyant density of backfill	
γ	=	Wet density of backfill	
p_a	=	Unit backfill active force	(eq 2-6)
R_a	=	Resultant of active forces	(eq 3-2)
y	=	Distance from centroid of active forces to point of zero shear	(eq 3-3)
c	=	Cohesion of subsoil	
q	=	Effective soil pressure at dredge line	(eq 3-4)
p_p	=	Unit subsoil passive force	
	=	4c - q	(eq 5-2)

Anchor Pull Force:

For $h_w < H$:

$T = R_a - D p_p$ (eq 5-3)

For $h_w = H$:

$$T = .5 \gamma z^2 K_a \qquad \text{(eq 5-4)}$$

<u>Maximum Bending Moment</u>:

For $h_w < H$:

$$Mmax = T (z - h_1) - .5 \gamma h_w^2 K_a (z - .67h_w) - .5 \times \gamma h_w K_a (z - h_w)^2 - \gamma_b K_a (z - h_w)^3 / 6 \qquad \text{(eq 5-5)}$$

z = Distance from surface where shear equals zero

$$.5 \gamma h_w^2 K_a - T + \gamma h_w K_a (z - h_w) + .5 \gamma_b \times (z - h_w)^2 = 0 \qquad \text{(eq 4-4)}$$

For $h_w = H$:

$$Mmax = T (z - h_1) - \gamma z^3 K_a / 6 \qquad \text{(eq 5-6)}$$

5.1.3 Example Problems

Three problems were solved using PILE.4 program, Option 7 selection. These problems are include in Appendix B, Sheets 16 through 19 and results are summarized on Table 7.

The backfill's friction angle ranged from 30 to 33 degrees for these problems. Minimum pile depth results deviated from the author's solutions (Das 1983) of 0.0 to 6.6 percent (three solutions) and anchor pull force 0.1 to 6.4 percent. The maximum moment was not calculated by the author.

5.1.4 Design Graph ($\gamma_b = .5\gamma$)

PILE.4 program, Option 8 selection was used to develop Figure 10. Computer computations were calculated in the English system and are included in Appendix F. Six solutions are summarized on Table 8, for α equals 0, 0.5 and 1.0. The backfill's friction angle selected is 28 and 37 from the graph data. At a zero degree backfill slope the cohesion ratio $[(2q_u - q)/\gamma_b K_a H]$ are 7.67 and 16.18, respectively.

Minimum pile depth ratio (D/H) results deviated from the Teng's graph (USS 1975, Figure 26) by 0.0 percent, minimum anchor pull deviated by 0.0 percent and maximum moment ratio ($M_{max}/\gamma_b K_a \times H^3$) deviated by 0.0 percent. Data results are plotted on semi-logarithmic paper on Figure 10 as described in Section 2.1.4.

5.1.5 New Graphs ($\gamma b = .4\gamma$, $.6\gamma$)

Two new graphs were developed for various soil conditions and water levels. These include Figures 11 and 12 for a backfill buoyant density of $\gamma b = .4\gamma$ and $.6\gamma$, respectively.

TABLE 7
CASE 4 SUMMARY
OPTION 7
ANCHORED STEEL SHEET PILE
COHESIVE SUBSOIL AND GRANULAR BACKFILL

PROBLEM	REF	SYSTEM	FRICTION ANGLE	MINIMUM EMBEDMENT DEPTH, D			BACKFILL ACTIVE FORCE, R_a			MAXIMUM MOMENT, Mmax			ANCHOR PULL FORCE, T		
				TEXT (1)	PILE4	DEVIATION	TEXT (1)	PILE4	DEVIATION	TEXT (1)	PILE4	DEVIATION	TEXT (1)	PILE4	DEVIATION
13-4	1	S.I.	30° (2)	1.1 m	1.1 m	0.0 %	162.2 kN/m	162.2 kN/m	0.0 %	NA	180.7 kN-m/m	--	71.2 kN/m	71.3 kN/m	0.1 %
13-12A	1	English	30°	1.5 ft	1.6 ft	6.6 %	NA	8,312 lbs/ft	--	NA	20,380 ft-lbs/ft	--	3,900 lbs/ft	3,755 lbs/ft	3.7 %
13-12D	1	S.I.	33° (2)	0.1 m	0.1 m	0.0 %	NA	113.1 kN/m	--	NA	73.9 kN-m/m	--	51.0 kN/m	47.7 kN/m	6.4 %

Notes:
1. These answers are from the referenced text books.
2. The wall friction is 17 degrees for this problem.

Reference:
1. Das, Braja 1983, Advanced Foundation Design.

TABLE 8
CASE 4 SUMMARY
OPTION 8
ANCHORED STEEL SHEET PILE
COHESIVE SUBSOIL AND GRANULAR BACKFILL

α RATIO	COHESION RATIO	FRICTION ANGLE	DEPTH RATIO			MOMENT RATIO			ANCHOR PULL RATIO		
			GRAPH (1)	PILE.4	DEVIATION	GRAPH (1)	PILE.4	DEVIATION	GRAPH (1)	PILE.4	DEVIATION
0	6.0	30°	0.05	0.05	0.0 %	0.04	0.04	0.0 %	0.23	0.23	0.0 %
0	0.1	30°	1.42	1.42	0.0 %	0.11	0.11	0.0 %	0.36	0.36	0.0 %
0.5	6.0	30°	0.07	0.07	0.0 %	0.08	0.08	0.0 %	0.43	0.43	0.0 %
0.5	0.1	30°	1.97	1.97	0.0 %	0.209	0.209	0.0 %	0.68	0.68	0.0 %
1.0	6.0	30°	0.09	0.09	0.0 %	0.10	0.10	0.0 %	0.47	0.47	0.0 %
1.0	0.1	30°	2.23	2.23	0.0 %	0.26	0.26	0.0 %	0.78	0.78	0.0 %

Notes:
1. α Ratio = γ_b / γ = Buoyant Density/ Wet Density
2. Cohesion Ratio = $(2q_u - q)/ \gamma_b K_a H$
   K_a = Coefficient of Active Pressure
   q = Effective Soil Pressure At Dredge Line
   q_u = 2 x Subsoil Cohesion
3. Depth Ratio = D/ H = Minimum Pile Embedment Depth/ Pile Height Above Dredge Line
4. Moment Ratio = $Mmax/ \gamma_b K_a H^3$
5. Anchor Pull Ratio = $T/ \gamma_b K_a H^2$
   T = Anchor Pull Force

Reference:

1. United States Steel Corporation July 1975, Steel Sheet Piling Design Manual, Figure 26.

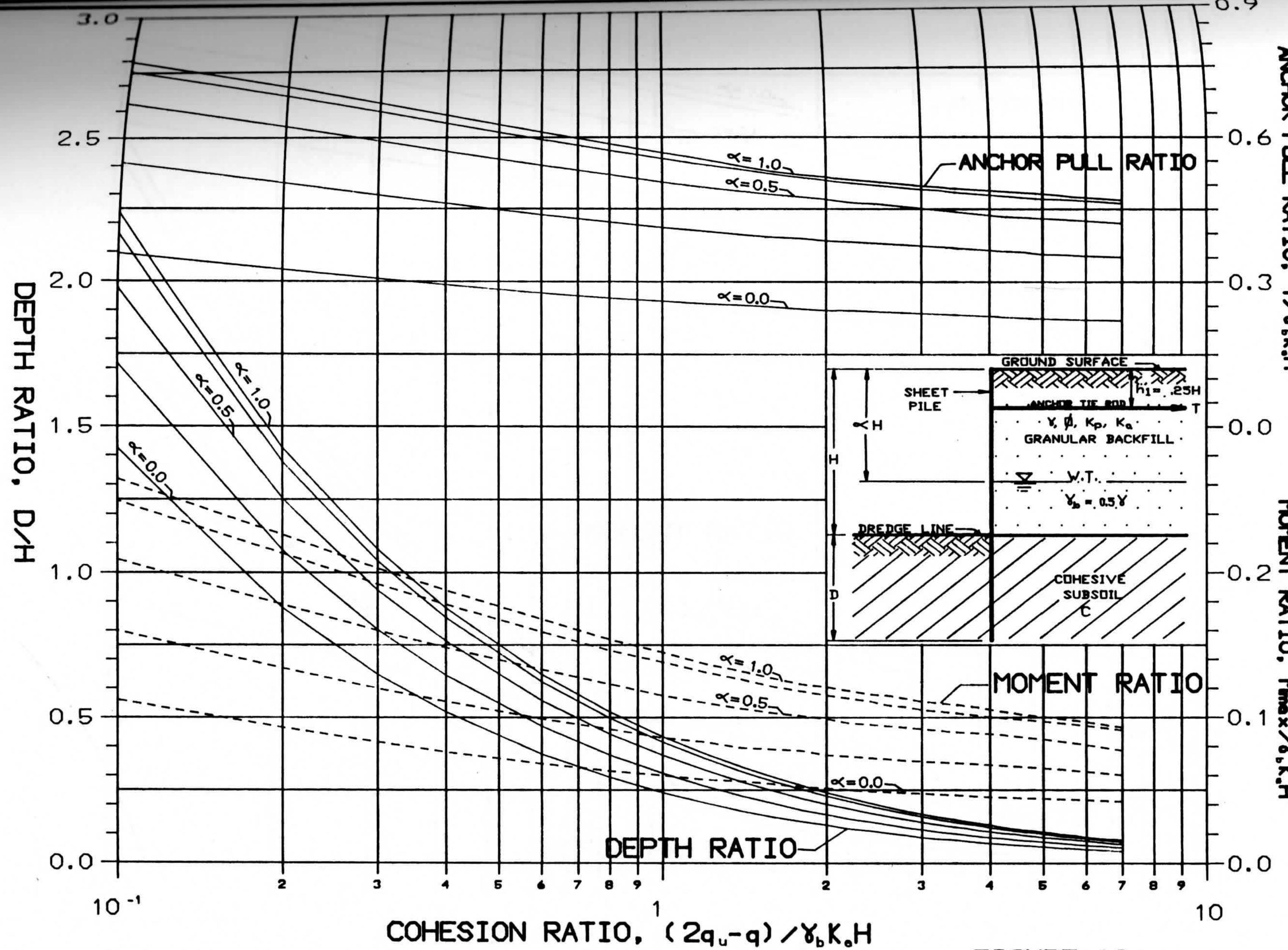


FIGURE 10
ANCHOR STEEL SHEET PILE
COHESIVE SUBSOIL WITH GRANULAR BACKFILL
$\gamma_b = 0.5\gamma$

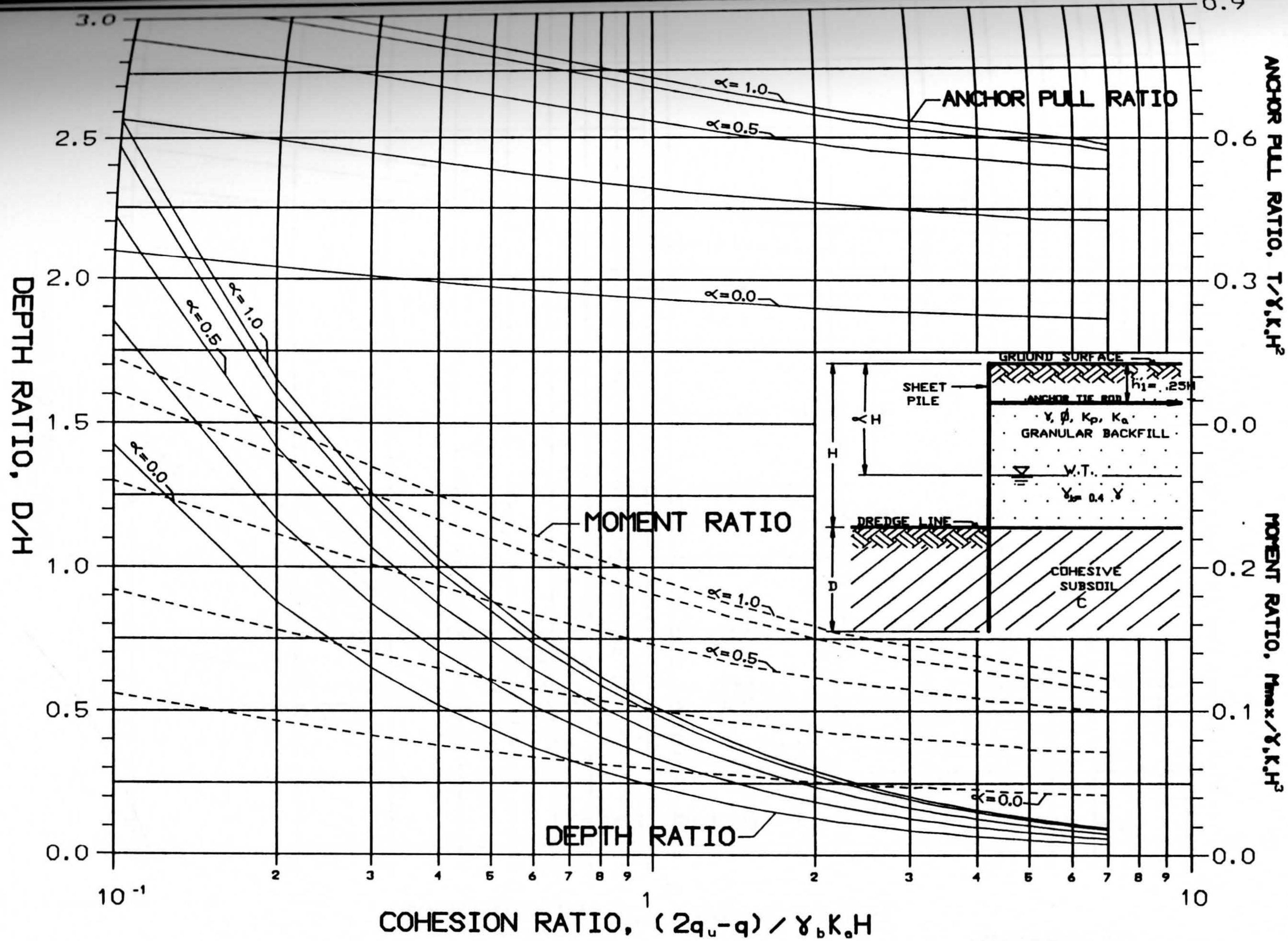


FIGURE 11
ANCHOR STEEL SHEET PILE
COHESIVE SUBSOIL WITH GRANULAR BACKFILL
$\gamma_b = 0.4\gamma$

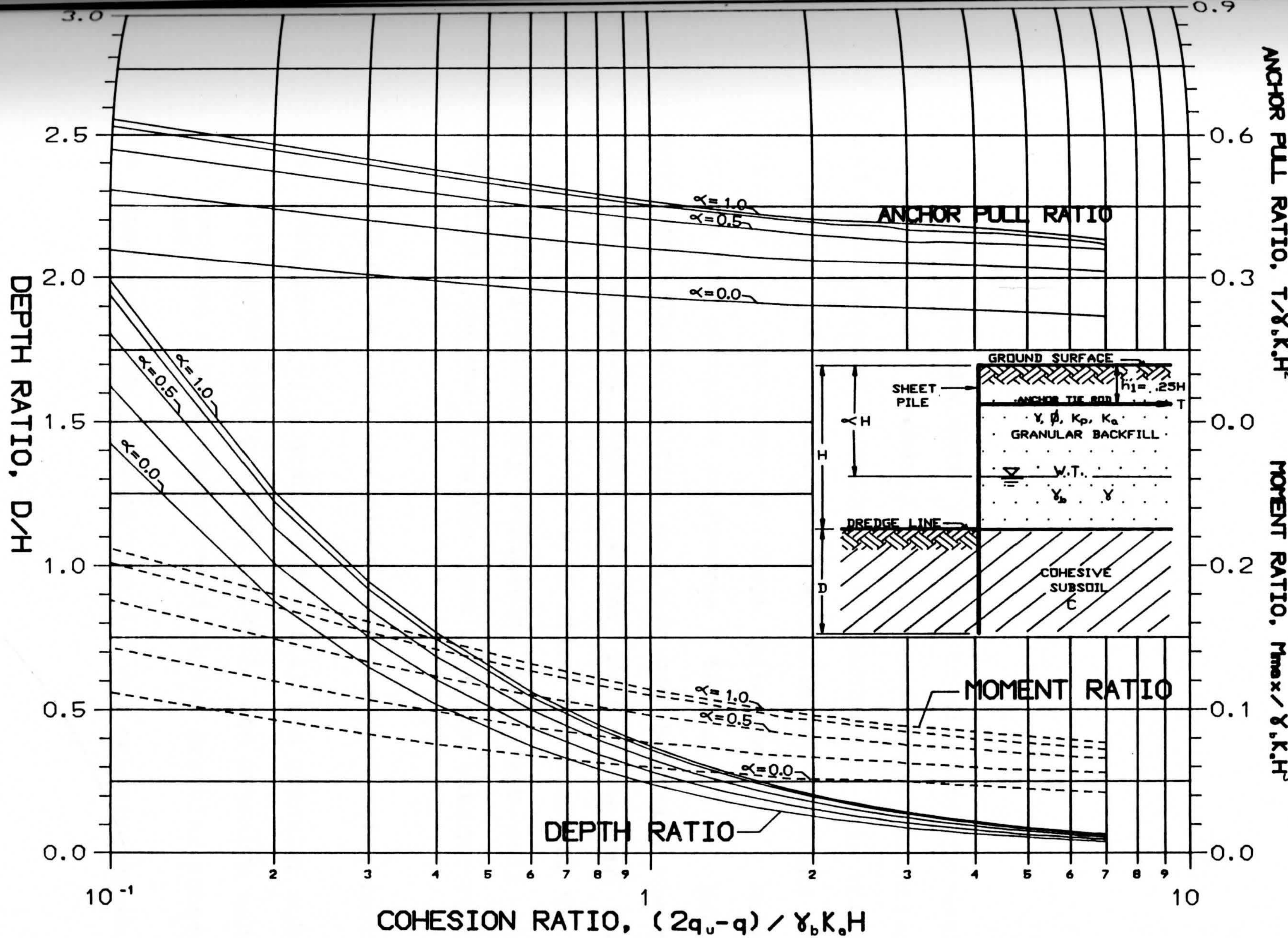


FIGURE 12
ANCHOR STEEL SHEET PILE
COHESIVE SUBSOIL WITH GRANULAR BACKFILL
$\gamma_b = 0.6\gamma$

CHAPTER 6

SUMMARY

Twelve graphs were developed to simplify the design of cantilever and anchored sheet piles. Complex derivations and their reduced equations are presented in this thesis for reference. These graphs will minimize the time and greatly improve the accuracy of sheet pile design. Graphical results are presented on Figures 1 through 12 in preceding sections. The practicing engineer can determine the pile's minimum embedment depth, anchor pull force and maximum moment. The time savings will allow the designer to spend time more productively evaluating different soil loading conditions and analyzing the cost of these alternatives.

Four cases for sheet piles were analysed which include:

- Cantilever with granular backfill and granular subsoil;
- Cantilever with granular backfill and cohesive subsoil;
- Anchored with granular backfill and granular subsoil; and,
- Anchored with granular backfill and cohesive subsoil.

The practicing engineer could also utilize the PILE.4 program included in Appendix G. Individual problems can be evaluated by the designer with an optional spreadsheet printout for inclusion into any calculation brief.

APPENDIX A

PILE.4 PROGRAM

```
10 ' NOVEMBER 1, 1991                                        PILE.4
20 '                         JOSEPH F. STOCK, JR., PE
30 '
40 '                         2253 SUNSHINE PLACE
50 '                         COLUMBUS, OHIO 43232
60 '                         614-575-9126
70 '
80 '
90 '                         YOUNGSTOWN STATE UNIVERSITY
100 '                        ENGINEERING GRADUATE THESIS
110 '
120 '                        DR. JOHN CERNICA-PROFESSOR
130 'PILE.4
140 'BASIC PROGRAMMING
150 '
160 'OPTIONS 1 AND 2
170 'CANTILEVER SHEET PILE EMBEDDED IN GRANULAR SUBSOIL WITH GRANULAR BACKFILL:
180 'USING CERNICA/DAS' EQUATION FOR DEPTH
190 'USING CERNICA'S EQUATION FOR MOMENT
200 '
210 'OPTIONS 3 AND 4
220 'CANTILEVER SHEET PILE EMBEDDED IN COHESIVE SUBSOIL WITH GRANULAR BACKFILL:
230 'USING CERNICA/BOWLES/DAS' EQUATION FOR DEPTH
240 'USING CERNICA/DAS' EQUATION FOR MOMENT
250 '
260 'OPTIONS 5 AND 6
270 'ANCHOR SHEET PILE EMBEDDED IN GRANULAR SUBSOIL WITH GRANULAR BACKFILL:
280 'USING CERNICA/BOWLES/DAS' EQUATION FOR DEPTH
290 'USING CERNICA/DAS' EQUATION FOR MOMENT
300 '
310 'OPTIONS 7 AND 8
320 'ANCHOR SHEET PILE EMBEDDED IN COHESIVE SUBSOIL WITH GRANULAR BACKFILL:
330 'USING CERNICA/BOWLES/DAS' EQUATION FOR DEPTH
340 'USING CERNICA/DAS' EQUATION FOR MOMENT
350 NSL=0:PRC=0
360 '
370 '
380 COLOR 15,1,1
390 CLS
400 PRINT TAB(24)"INTERACTIVE COMPUTER PROGRAMS"
410 PRINT TAB(24)"                FOR"
420 PRINT TAB(25)"FLEXIBLE SHEET PILE DESIGN":PRINT
430 PRINT TAB(26)"BY:  JOSEPH F. STOCK, JR.":PRINT
440 PRINT TAB(31)"NOVEMBER 1991":PRINT
450 PRINT TAB(15)"SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS"
460 PRINT TAB(15)"FOR A MASTER OF SCIENCE DEGREE IN CIVIL ENGINEERING":PRINT
470 PRINT TAB(25)"YOUNGSTOWN STATE UNIVERSITY"
480 PRINT :PRINT :PRINT :PRINT
490 'PRINT "REFERENCES:  ":PRINT
500 'PRINT "1.  'STEEL SHEET PILING DESIGN MANUAL', BY UNITED STATES STEEL, JULY
```

```
1975.":PRINT
510 'PRINT "2.  'GEOTECHNICAL ENGINEERING', BY JOHN CERNICA, PHD, PE, 1982.":PRI
NT
520 'PRINT "3.  'FOUNDATION ANALYSIS AND DESIGN, 3RD EDITION', BY J.E. BOWLES, 1
982.":PRINT
530 'PRINT "4.  'PRINCIPLES OF FOUNDATION ENGINEERING', BY BRAJA M. DAS, 1984.":
PRINT :PRINT
540 INPUT "PRESS RETURN KEY TO CONTINUE!",PRC
550 IF PRC=0 THEN 560 ELSE 2810
560 CLS:LOCATE 5,1:PRINT "GENERAL DESCRIPTION":PRINT
570 PRINT "THIS PROGRAM WAS DEVELOPED TO ANALYSE BACKFILL SOIL PRESSURES AND TO
DESIGN FLEXIBLE SHEET PILES."
580 LOCATE 20,1:INPUT "PRESS RETURN KEY TO CONTINUE!",PRC
590 IF PRC=0 THEN 600 ELSE 2810
600 CLS
610 '
620 PRINT "SHEET PILE DESIGN OPTIONS":PRINT:Z=0
630 PRINT "1.  CALCULATE MINIMUM DEPTH AND MAXIMUM MOMENT OF A CANTILEVER"
640 PRINT "      PILE EMBEDDED IN GRANULAR SOIL, WITH GRANULAR BACKFILL."
650 PRINT "2.  DEVELOP GRAPH OF A CANTILEVER PILE EMBEDDED IN GRANULAR "
660 PRINT "      SOIL, WITH GRANULAR BACKFILL."
670 PRINT "3.  CALCULATE MINIMUM DEPTH AND MAXIMUM MOMENT OF A CANTILEVER"
680 PRINT "      PILE IN COHESIVE SOIL, WITH GRANULAR BACKFILL."
690 PRINT "4.  DEVELOP GRAPH FOR A CANTILEVER PILE EMBEDDED IN COHESIVE "
700 PRINT "      SOIL, WITH GRANULAR BACKFILL."
710 PRINT "5.  CALCULATE MINIMUM DEPTH AND MAXIMUM MOMENT OF AN ANCHORED "
720 PRINT "      PILE EMBEDDED IN GRANULAR SOIL, WITH GRANULAR BACKFILL."
730 PRINT "6.  DEVELOP GRAPH OF AN ANCHORED PILE EMBEDDED IN GRANULAR SOIL, "
740 PRINT "      WITH GRANULAR BACKFILL."
750 PRINT "7.  CALCULATE MINIMUM DEPTH AND MAXIMUM MOMENT OF AN ANCHORED
760 PRINT "      PILE EMBEDDED IN COHESIVE SOIL, WITH GRANULAR BACKFILL."
770 PRINT "8.  DEVELOP GRAPH OF AN ANCHORED PILE EMBEDDED IN COHESIVE SOIL, "
780 PRINT "      WITH GRANULAR BACKFILL."
790 PRINT "9.  QUIT":PRINT
800 INPUT"SELECT OPTION 1 THROUGH 9:",SOT
810 IF SOT=1 THEN 900
820 IF SOT=2 THEN 5160
830 IF SOT=3 THEN 900
840 IF SOT=4 THEN 6760
850 IF SOT=5 THEN 900
860 IF SOT=6 THEN 5160
870 IF SOT=7 THEN 900
880 IF SOT=8 THEN 6760
890 GOTO 800
900 '
910 '
920 '
930 '                          OPTIONS 1, 3, 5 AND 7
940 '
950 CAD=0:WLT=0:CLS
```

```
960 INPUT "1.  FILE NO.          ";REC$
970 INPUT "2.                    ";CY$
980 INPUT "3.                    ";PT$
990 INPUT "4.                    ";SE$
1000 INPUT "5.                    ";CO$
1010 INPUT "6.                    ";TP$
1020 INPUT "7.  DESIGNER          ";DR$
1030 INPUT "8.  DATE              ";DE$
1040 INPUT "CHANGE ANY DATA?  (ENTER 0=NO, 1=YES)",CAD
1050 IF CAD=0 THEN 1240
1060 INPUT "WHICH LINE TO BE REVISED";WLT
1070 IF WLT=1 THEN 1080 ELSE 1090
1080 INPUT REC$
1090 IF WLT=2 THEN 1100 ELSE 1110
1100 INPUT CY$
1110 IF WLT=3 THEN 1120 ELSE 1130
1120 INPUT PT$
1130 IF WLT=4 THEN 1140 ELSE 1150
1140 INPUT SE$
1150 IF WLT=5 THEN 1160 ELSE 1170
1160 INPUT CO$
1170 IF WLT=6 THEN 1180 ELSE 1190
1180 INPUT TP$
1190 IF WLT=7 THEN 1200 ELSE 1210
1200 INPUT DR$
1210 IF WLT=8 THEN 1220 ELSE 1040
1220 INPUT DE$
1230 GOTO 1040
1240 IF SOT=1 THEN 1280
1250 IF SOT=3 THEN 8500
1260 IF SOT=5 THEN 1280
1270 IF SOT=7 THEN 8500
1280 '
1290 '
1300 '
1310 '
1320 '                    OPTIONS 1 AND 5 (CONTINUED)
1330   GOSUB 1350
1340 GOTO 2490
1350 '
1360 '
1370 '
1380 '
1390 '                OPTIONS 1, 3, 5 AND 7 (CONTINUED)
1400 INPUT "ENGLISH(0) OR METRIC(1) SYSTEM";ENG
1410 IF ENG=1 THEN 1440
1420 '
                             INPUT SOIL TEST DATA
1430 INPUT "1.  BACKFILL WET DENSITY (PCF)";BWD:GOTO 1450
1440 INPUT "1.  BACKFILL WET DENSITY (kN/CUBIC METER)";MBWD:GOTO 1460
1450 INPUT "2.  BACKFILL BUOYANT DENSITY (PCF)";BBD:GOTO 1470
```

```
1460 INPUT "2.  BACKFILL BUOYANT DENSITY (kN/CUBIC METER)";MBBD
1470 INPUT "3.  BACKFILL FRICTION ANGLE (DEGREES)";BFA
1480 INPUT "4.  WALL FRICTION ANGLE (DEGREES)";BBB
1490 IF ENG=1 THEN 1510
1500 INPUT "5.  HEIGHT OF BACKFILL (FEET)";HHB:GOTO 1520
1510 INPUT "5.  HEIGHT OF BACKFILL (METERS)";MHHB
1520 INPUT "6.  SLOPE OF BACKFILL'S GROUND LINE (DEGREES)";SOB
1530 IF ENG=1 THEN 1550
1540 INPUT "7.  GROUND WATER DEPTH (FEET)";GWD:IF SOT=3 THEN 1580 ELSE 1560
1550 INPUT "7.  GROUND WATER DEPTH (METERS)";MGWD:IF SOT=3 THEN 1580 ELSE 1570
1560 INPUT "8.  UNIFORM SURCHARGE LOAD (PSF)";SURL:GOTO 1580
1570 INPUT "8.  UNIFORM SURCHARGE LOAD (kN/SMETER)";MSURL:GOTO 1580
1580 PRINT :PRINT "WALL FRICTION ANGLES"
1590 PRINT "  (STEEL SHEET PILES AGAINST:)"
1600 PRINT "o  CLEAN GRAVEL, GRAVEL-SAND MIXTURE=        22 DEGREES"
1610 PRINT "o  CLEAN SAND, SILTY SAND-GRAVEL MIXTURE=   17 DEGREES"
1620 PRINT "o  SILTY SAND, GRAVEL OR SAND MIXED"
1630 PRINT "     WITH SILT OR CLAY=                      14 DEGREES"
1640 PRINT "o  FINE SANDY SILT, NON-PLASTIC SILT=        11 DEGREES"
1650 INPUT "CHANGE ANY DATA?  (ENTER 0=NO, 1=YES)",CAD
1660 IF CAD=0 THEN 2170
1670 INPUT "WHICH LINE TO BE REVISED";WLT
1680 IF ENG=1 THEN 1720
1690 IF WLT=1 THEN 1700 ELSE 1750
1700 INPUT BWD
1710 GOTO 1650
1720 IF WLT=1 THEN 1730 ELSE 1780
1730 INPUT MBWD
1740 GOTO 1650
1750 IF WLT=2 THEN 1760 ELSE 1810
1760 INPUT BBD
1770 GOTO 1650
1780 IF WLT=2 THEN 1790 ELSE 1840
1790 INPUT MBBD
1800 GOTO 1650
1810 IF WLT=3 THEN 1820 ELSE 1870
1820 INPUT BFA
1830 GOTO 1650
1840 IF WLT=3 THEN 1850 ELSE 1900
1850 INPUT BFA
1860 GOTO 1650
1870 IF WLT=4 THEN 1880 ELSE 1930
1880 INPUT BBB
1890 GOTO 1650
1900 IF WLT=4 THEN 1910 ELSE 1960
1910 INPUT BBB
1920 GOTO 1650
1930 IF WLT=5 THEN 1940 ELSE 1990
1940 INPUT HHB
1950 GOTO 1650
```

```
1960 IF WLT=5 THEN 1970 ELSE 2020
1970 INPUT MHHB
1980 GOTO 1650
1990 IF WLT=6 THEN 2000 ELSE 2050
2000 INPUT SOB
2010 GOTO 1650
2020 IF WLT=6 THEN 2030 ELSE 2080
2030 INPUT SOB
2040 GOTO 1650
2050 IF WLT=7 THEN 2060 ELSE 2110
2060 INPUT GWD
2070 GOTO 1650
2080 IF WLT=7 THEN 2090 ELSE 2140
2090 INPUT MGWD
2100 GOTO 1650
2110 IF WLT=8 THEN 2120 ELSE 1650
2120 INPUT SURL
2130 GOTO 1650
2140 IF WLT=8 THEN 2150 ELSE 1650
2150 INPUT MSURL
2160 '
2170 IF ENG=0 THEN 2230
2180 BWD=MBWD*6.368
2190 BBD=MBBD*6.368
2200 HHB=MHHB*3.28
2210 GWD=MGWD*3.28
2220 SURL=MSURL*20.89
2230 PRINT :PRINT "SELECT COULOMB OR RANKINE EQUATION FOR Ka AND Kp":PRINT
2240 PRINT "SELECT Ka AND Kp.   EITHER 'COU' OR 'RAN'"
2250 PRINT :PRINT :INPUT "USE 'COU' (ENTER 0=NO, 1=YES)";SEL
2260 IF SEL=1 THEN 2300 ELSE 2270
2270 IF SEL=0 THEN 2430 ELSE 2280
2280 'BOTH COULOMB AND RANKINE
2290 GOTO 2230
2300 'COULOMB ONLY
2310 SINA=(SIN((90+BFA)*3.14159/180))^2 :'  COUMOMB'S EQUATION CONSIDERS THE WAL
L FRICTION ANGLE.
2320 SINB=(SIN((90-BFA)*3.14159/180))^2
2330 SINC=SIN((90-BBB)*3.14159/180)
2340 SIND=SIN((90+BBB)*3.14159/180)
2350 SINE=SIN((BFA+BBB)*3.14159/180)
2360 SINF=SIN((BFA-SOB)*3.14159/180)
2370 SING=SIN((BFA+SOB)*3.14159/180)
2380 SINH=SIN((90+SOB)*3.14159/180)
2390 KA=SINA/(SINC*(1+SQR((SINE*SINF)/(SINC*SINH)))^2):'REFERENCE 3, EQ 11-3
2400 KP=SINB/(SIND*(1-SQR((SINE*SING)/(SIND*SINH)))^2):'REFERENCE 3, EQ 11-6
2410 GOTO 2480
2420 GOTO 2480
2430 'RANKINE ONLY
2440 COSA=COS(SOB*3.14159/180):'  COUMOMB'S EQUATION CONSIDERS THE WALL FRICTION
```

```
ANGLE.
2450 COSB=COS(BFA*3.14159/180)
2460 KA=COSA*(COSA-(COSA^2-COSB^2)^.5)/(COSA+(COSA^2-COSB^2)^.5):'REFERENCE 3, E
Q 11-7
2470 KP=COSA*(COSA+(COSA^2-COSB^2)^.5)/(COSA-(COSA^2-COSB^2)^.5):'REFERENCE 3, E
Q 11-9
2480 RETURN
2490 '
2500 '
2510 '
2520 '                          OPTIONS 1 AND 5 (CONTINUED)
2530 D=.2*HHB:JON=0
2540 N=0 :NN=0
2550 RG=GWD*SURL*KA
2560 IF GWD=0 THEN 2590
2570 PA=KA*(BWD*GWD+BBD*(HHB-GWD))+RG/GWD:'    Pa
2580 GOTO 2600
2590 PA=KA*(BWD*GWD+BBD*(HHB-GWD)):'     Pa
2600 A=PA/(BBD*(KP-KA)):'         a
2610 RC=.5*BWD*GWD^2*KA+RG:'      R1
2620 IF GWD=0 THEN 2650
2630 M=BWD*GWD*KA+RG/GWD:'        P1
2640 GOTO 2660
2650 M=BWD*GWD*KA
2660 RD=M*(HHB-GWD):'             R2
2670 RE=PA*.5*A:'                 R4
2680 N=PA-M
2690 RF=.5*N*(HHB-GWD):'          R3     RF=.5*BBD*KA*(HHB-GWD)^2
2700 RA=RC+RD+RE+RF
2710 MGWD=GWD/3.28
2720 MRC=RC*3.28/224.8
2730 MRD=RD*3.28/224.8
2740 MRF=RF*3.28/224.8
2750 MRA=RA*3.28/224.8
2760 MRE=RE*3.28/224.8
2770 YY=(RC*(A+HHB-GWD*2/3)+RD*(A+.5*(HHB-GWD))+RE*(2*A/3)+RF*(A+(HHB-GWD)*1/3))
/RA:'    y
2780 IF SOT=5 THEN 2990
2790 '                          OPTION 1 (CONTINUED)
2800 CLS:LOCATE 10,20:PRINT"THINKING"
2810 GOTO 2830
2820 D=D+.1
2830 LOCATE 12,20:PRINT JON
2840 Y=D-A
2850 PP=BBD*(KP-KA)*Y:'        Pp
2860 MELA=(BWD*GWD+BBD*(HHB-GWD))*KP
2870 MELB=BBD*D*(KP-KA)
2880 PPL=MELA+MELB:'           Pp'
2890 ZB=(PP*Y-2*RA)/(PP+PPL):'      z
2900 C=PP/Y
```

```
2910 MM=Y^3-2*RA*Y^2/PPL-6*RA*((1/C)+YY/PPL)*Y-(2*RA/(C*PPL))*(3*PPL*YY+2*RA):'
        DEVIVATION 6
2920 'MM=6*RA*(Y+YY)-PP*Y^2+(PP+PPL)*ZB^2:'     DERIVATION 1
2930 JON=1+JON
2940 IF MM<0 THEN 2820
2950 XDIST=SQR(2*RA/(BBD*(KP-KA)))
2960 MMAX=RA*(YY+((2/3)*XDIST))
2970 XX=QQQ-GWD
2980 GOTO 3320
2990 '                          OPTION 5 (CONTINUED)
3000 IF ENG=1 THEN 3020
3010 INPUT"ANCHOR DEPTH FROM SURFACE (FEET)";LL:GOTO 3030
3020 INPUT"ANCHOR DEPTH FROM SURFACE (METERS)";MLL
3030 INPUT "CHANGE ANY DATA?  (ENTER 0=NO, 1=YES)",CAD
3040 IF CAD=1 THEN 3000
3050 IF ENG=1 THEN 3090
3060 MLL=LL/3.28:CLS:LOCATE 10,20:PRINT "THINKING":GOTO 3110
3070 'IF CAD=1 THEN 2760
3080 '
3090 CLS:LOCATE 10,20:PRINT"THINKING METRIC":LL=MLL*3.28
3100 '
3110 D=D+.05:Y=D-A
3120 MM=Y^3+1.5*Y^2*(HHB+A-LL)-3*RA*(HHB+A-YY-LL)/(BBD*(KP-KA))
3130 JON=JON+1:LOCATE 12,20:PRINT JON
3140 IF MM<0 THEN 3110
3150 GAM=GWD/HHB
3160 F=RA-.5*BBD*(KP-KA)*Y^2
3170 MF=F*3.28/224.8
3180 IF GAM<1 THEN 3260
3190 BON=0:JOE=0:Z=GWD*.5:GOTO 3210
3200 Z=Z+.05
3210 JOE=-F+.5*BWD*Z^2*KA
3220 BON=BON+1:LOCATE 14,20:PRINT BON
3230 IF JOE<0 THEN 3200
3240 MMAX=F*(Z-LL)-.5*BWD*Z^2*KA*(Z*.33)
3250 GOTO 3320
3260 BON=0:JOE=0:Z=GWD:GOTO 3280
3270 Z=Z+.05
3280 JOE=-F+.5*M*GWD+M*(Z-GWD)+.5*KA*BBD*(Z-GWD)^2
3290 BON=BON+1:LOCATE 14,20:PRINT BON
3300 IF JOE<0 THEN 3270
3310 MMAX=F*(Z-LL)-.5*BWD*GWD^2*KA*(Z-.67*GWD)-.5*BWD*GWD*KA*(Z-GWD)^2-BBD*KA*(Z
-GWD)^3/6
3320 MMMAX=MMAX/224.8'              OPTIONS 1 AND 5
3330 MBWD=BWD/6.368
3340 FRATIO=F/(BBD*KA*HHB^2)
3350 FRATIO=INT(100*(FRATIO+.005))/100
3360 MBBD=BBD/6.368
3370 MCOH=COH/20.89
3380 MHHB=HHB/3.28
```

```
3390 MD=D/3.28
3400 MYY=YY/3.28
3410 MA=A/3.28
3420 MZB=ZB/3.28
3430 MZ=Z/3.28
3440 GAM=GWD/HHB
3450 DRA=D/HHB:'   DEPTH RATIO
3460 KPKA=KP/KA
3470 MRATIO=MMAX/(BBD*KA*HHB^3)
3480 MPP=PP/20.89
3490 MPPL=PPL/20.89
3500 MPA=PA/20.89
3510 MSURL=SURL/20.89
3520 '
3530 MXDIST=XDIST/3.28
3540 MBWD=INT(100*(MBWD+.005))/100
3550 BWD=INT(100*(BWD+.005))/100
3560 MBBD=INT(100*(MBBD+.005))/100
3570 BBD=INT(100*(BBD+.005))/100
3580 MCOH=INT(100*(MCOH+.005))/100
3590 MHHB=INT(100*(MHHB+.005))/100
3600 SURL=INT(100*(SURL+.005))/100
3610 MSURL=INT(100*(MSURL+.005))/100
3620 MGWD=INT(100*(MGWD+.005))/100
3630 MD=INT(100*(MD+.005))/100
3640 MYY=INT(100*(MYY+.005))/100
3650 MZB=INT(100*(MZB+.005))/100
3660 MMMAX=INT(100*(MMMAX+.005))/100
3670 MRC=INT(100*(MRC+.005))/100
3680 MRD=INT(100*(MRD+.005))/100
3690 MRF=INT(100*(MRF+.005))/100
3700 MRE=INT(100*(MRE+.005))/100
3710 MRA=INT(100*(MRA+.005))/100
3720 RA=INT(10*(RA+.05))/10
3730 YY=INT(100*(YY+.005))/100
3740 KPKA=INT(100*(KPKA+.005))/100
3750 MRATIO=INT(100*(MRATIO+.005))/100
3760 DRA=INT(100*(DRA+.005))/100
3770 MPP=INT(100*(MPP+.005))/100
3780 MPPL=INT(100*(MPPL+.005))/100
3790 MPA=INT(100*(MPA+.005))/100
3800 MA=INT(100*(MA+.005))/100
3810 PA=INT(100*(PA+.005))/100
3820 RC=INT(10*(RC+.05))/10
3830 NN=INT(10*(NN+.05))/10
3840 F=INT(10*(F+.05))/10
3850 MF=INT(10*(MF+.05))/10
3860 LL=INT(10*(LL+.05))/10
3870 MLL=INT(10*(MLL+.05))/10
3880 RD=INT(10*(RD+.05))/10
```

```
3890 GAM=INT(100*(GAM+.005))/100
3900 RF=INT(10*(RF+.05))/10
3910 RE=INT(10*(RE+.05))/10
3920 D=INT(100*(D+.005))/100
3930 A=INT(100*(A+.005))/100
3940 PP=INT(10*(PP+.05))/10
3950 PPL=INT(10*(PPL+.05))/10
3960 ZB=INT(100*(ZB+.005))/100
3970 Z=INT(100*(Z+.005))/100
3980 MZ=INT(100*(MZ+.005))/100
3990 MM=INT(100*(MM+.005))/100
4000 XDIST=INT(100*(XDIST+.005))/100
4010 MXDIST=INT(100*(MXDIST+.005))/100
4020 MMAX=INT(10*(MMAX+.05))/10
4030 KA=INT(1000*(KA+.0005))/1000
4040 KP=INT(1000*(KP+.0005))/1000
4050 IF SOT=1 THEN 4120
4060 PRINT "DEPTH";TAB(18)"CENTROID";TAB(52)"ANCHOR";TAB(63)"MOMENT":'  OPTION 5
4070 'PRINT "JOE=";JOE;"     Z=";Z
4080 PRINT TAB(3)"D";TAB(11)"Ra";TAB(21)"y";TAB(30)"a";TAB(40)"MM";TAB(55)"F";TA
B(64)"Mmax"
4090 PRINT TAB(1)"(FT)";TAB(10)"(LBS)";TAB(19)"(FT)";TAB(28)"(FT)";TAB(53)"(LBS)
";TAB(63)"(FT-LBS)":PRINT
4100 PRINT D;TAB(10)RA;TAB(19)YY;TAB(28)A;TAB(40)MM;TAB(54)F;TAB(64)MMAX:PRINT :
PRINT
4110 GOTO 4160
4120 PRINT "DEPTH";TAB(18)"CENTROID";TAB(63)"MOMENT":'      OPTION 1
4130 PRINT TAB(3)"D";TAB(11)"Ra";TAB(21)"y";TAB(30)"a";TAB(41)"Pp";TAB(49)"Pp'";
TAB(59)"z";TAB(64)"Mmax"
4140 PRINT TAB(1)"(FT)";TAB(10)"(LBS)";TAB(19)"(FT)";TAB(28)"(FT)";TAB(39)"(PSF)
";TAB(47)"(PSF)";TAB(57)"(FT)";TAB(63)"(FT-LBS)":PRINT
4150 PRINT D;TAB(10)RA;TAB(19)YY;TAB(28)A;TAB(39)PP;TAB(48)PPL;TAB(58)ZB;TAB(64)
MMAX:PRINT :PRINT
4160 INPUT "WANT A PRINT OUT?  (ENTER 0=NO, 1=YES)",WPP:'     OPTIONS 1 AND 5
4170 IF WPP=0 THEN 4740
4180 GOSUB 4770
4190 LPRINT "MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
MMMMMMMMM"
4200 IF SOT=1 THEN 4230
4210 LPRINT TAB(45)"INPUT DATA";TAB(70)"OPTION 5":LPRINT TAB(65)"PILE.4 PROGRAM"
:LPRINT
4220 GOTO 4240
4230 LPRINT TAB(45)"INPUT DATA";TAB(70)"OPTION 1":LPRINT TAB(65)"PILE.4 PROGRAM"
:LPRINT
4240 IF ENG=0 THEN 4260
4250 LPRINT TAB(68)"**":GOTO 4270
4260 LPRINT TAB(46)"**"
4270 LPRINT TAB(33)"ENGLISH UNITS";TAB(56)"METRIC UNITS"
4280 LPRINT "BACKFILL WET DENSITY=              ";BWD;"  PCF";TAB(55)MBWD;"  kN/CMET
ER"
```

```
4290 LPRINT "BACKFILL BUOYANT DENSITY=        ";BBD;"  PCF";TAB(55)MBBD;"  kN/CMET
ER"
4300 LPRINT "BACKFILL FRICTION ANGLE=         ";BFA;"  DEGREES";TAB(55)BFA;"  DEGR
EES"
4310 LPRINT "WALL FRICTION ANGLE=             ";BBB;"  DEGREES";TAB(55)BBB;"  DEGR
EES"
4320 LPRINT "HEIGHT OF BACKFILL=              ";HHB;"  FEET";TAB(55)MHHB;"  METERS
"
4330 LPRINT "SLOPE OF BACKFILL=               ";SOB;"  DEGREES";TAB(55)SOB;"  DEGR
EES"
4340 LPRINT "GROUND WATER DEPTH=              ";GWD;"  FEET";TAB(55)MGWD;"  METERS
"
4350 LPRINT "UNIFORM SURCHARGE LOAD=          ";SURL;"  PSF";TAB(55)MSURL;"  kN/SM
ETER"
4360 IF SOT=1 THEN 4380
4370 LPRINT "ANCHOR DEPTH =                  ";LL;"  FEET";TAB(55)MLL;"  METERS":
LPRINT
4380 LPRINT "MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
MMMMMMMMMM"
4390 LPRINT TAB(45)"OUTPUT DATA":LPRINT
4400 LPRINT TAB(33)"ENGLISH UNITS";TAB(55)"METRIC UNITS"
4410 LPRINT "BACKFILL:"
4420 LPRINT "ACTIVE COEFFICIENT,Ka=           ";KA;TAB(55)KA
4430 LPRINT "PASSIVE COEFFICIENT,Kp=          ";KP;TAB(55)KP
4440 LPRINT "Kp/Ka=                           ";KPKA;TAB(55)KPKA
4450 LPRINT "ALPHA=                           ";GAM;TAB(55)GAM:LPRINT
4460 LPRINT "PILE DEPTH,D=                    ";D;"  FEET";TAB(55)MD;"  METERS"
4470 LPRINT "D/H=                             ";DRA;TAB(55)DRA:LPRINT
4480 IF SOT=5 THEN 4490 ELSE 4530
4490 LPRINT "Z=                               ";Z;"  FT";TAB(55)MZ;"  METERS"
4500 LPRINT "ANCHOR FORCE, F=                 ";F;"  LBS/FT";TAB(55)MF;"  kN/m"
4510 LPRINT "F/(PHI'*KA*H^2)=                 ";FRATIO;TAB(55)FRATIO:LPRINT
4520 GOTO 4600
4530 LPRINT "CENTROID,Y=                      ";YY;"  FEET";TAB(55)MYY;"  METERS"
4540 LPRINT "z=                               ";ZB;"  FEET";TAB(55)MZB;"  METERS"
4550 LPRINT "DISTANCE TO PIVOT POINT,a=       ";A;"  FEET";TAB(55)MA;"  METERS"
4560 LPRINT "Pa=                              ";PA;"  PSF";TAB(55)MPA;"  kN/SMETER
"
4570 LPRINT "Pp=                              ";PP;"  PSF";TAB(55)MPP;"  kN/SMETER
"
4580 LPRINT "Pp'=                             ";PPL;"  PSF";TAB(55)MPPL;"  kN/SMET
ER"
4590 LPRINT "X DISTANCE=                      ";XDIST;"  FEET";TAB(55)MXDIST;"  ME
TERS"
4600 LPRINT "MOMENT,Mmax=                     ";MMAX;"  FT-LBS/FT";TAB(55)MMMAX;"
kN-m/m"
4610 LPRINT "Mmax/(PHI'*Ka*H^3)=              ";MRATIO;TAB(55)MRATIO:LPRINT
4620 LPRINT "BACKFILL ACTIVE FORCES:"
4630 LPRINT "   R1=                           ";RC;"  LBS/FT";TAB(55)MRC;"  kN/m"
4640 LPRINT "   R2=                           ";RD;"  LBS/FT";TAB(55)MRD;"  kN/m"
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```
4650 LPRINT "  R3=                                   ";RF;"  LBS/FT";TAB(55)MRF;"  kN/m"
4660 LPRINT "  R4=                                   ";RE;"  LBS/FT";TAB(55)MRE;"  kN/m"
4670 LPRINT "  TOTAL,Ra=                             ";RA;"  LBS/FT";TAB(55)MRA;"  kN/m"
4680 LPRINT CHR$(12)
4690 '
4700 '
4710 '
4720 GOTO 4160
4730 '
4740 IF COUNT=0 THEN 4760
4750 CLOSE #1
4760 END
4770 '
4780 '
4790 '
4800 '                   OPTIONS 5 AND 7 (CONTINUED)
4810 IF SOT=3 THEN 4950
4820 IF SOT=1 THEN 4950
4830 'DR$="JOSEPH F. STOCK, JR":DE$="APRIL 8, 1991"
4840 IF SOT=5 THEN 4870 ELSE 4900
4850 '
4860 '
4870 'OPTION 5
4880 LPRINT "ANCHORED SHEET PILE EMBEDDED IN GRANULAR SUBSOIL, WITH GRANULAR BAC
KFILL":LPRINT :LPRINT
4890 GOTO 5030
4900 'OPTION 7
4910 LPRINT "ANCHORED SHEET PILE EMBEDDED IN COHESIVE SUBSOIL, WITH GRANULAR BAC
KFILL":LPRINT :LPRINT
4920 GOTO 5030
4930 '
4940 '
4950 '                  OPTIONS 1, 3 AND 7 (CONTINUED)
4960 'DR$="JOSEPH F. STOCK, JR":DE$="APRIL 8, 1991"
4970 IF SOT=3 THEN 5010
4980 'OPTION 3
4990 LPRINT "CANTILEVER SHEET PILE EMBEDDED IN GRANULAR SUBSOIL, WITH GRANULAR B
ACKFILL":LPRINT
5000 GOTO 5030
5010 'OPTION 3
5020 LPRINT "CANTILEVER SHEET PILE EMBEDDED IN COHESIVE SUBSOIL, WITH GRANULAR B
ACKFILL":LPRINT:LPRINT
5030 LPRINT "FILE NO.:              ";REC$;TAB(65)"SHEET___OF___"
5040 LPRINT "                       ";CY$
5050 LPRINT "                       ";PT$
5060 LPRINT "                       ";SE$
5070 LPRINT "                       ";CO$
5080 LPRINT "                       ";TP$
5090 LPRINT "DESIGNER:              ";DR$
5100 LPRINT "DATE:                  ";DE$:LPRINT
```

```
5110 RETURN
5120 '
5130 '
5140 '
5150 '
5160 '
5170 '                              OPTIONS 2 AND 6 (CONTINUED)
5180 CLS
5190 INPUT "FILE NO.";REC$
5200 INPUT "FIGURE NO.";EN$
5210 INPUT "DESIGNER";DR$
5220 INPUT "DATE";DE$
5230 INPUT "1.  BACKFILL WET DENSITY (PCF)";BWD
5240 INPUT "2.  BACKFILL BUOYANT DENSITY FRACTION (EXAMPLE: 0.5 OF WET DENSITY)"
;BDF
5250 INPUT "3.  HEIGHT OF BACKFILL (FEET)";HHB
5260 '
5270 INPUT "CHANGE AND DATA?  (ENTER 0=NO, 1=YES)",CAD
5280 IF CAD=0 THEN 5390
5290 INPUT "WHICH LINE TO BE REVISED";WLT
5300 IF WLT=1 THEN 5310 ELSE 5320
5310 INPUT BWD
5320 IF WLT=2 THEN 5330 ELSE 5340
5330 INPUT BDF
5340 IF WLT=3 THEN 5350 ELSE 5270
5350 INPUT HHB
5360 '
5370 '
5380 '
5390 IF SOT=2 THEN 5480
5400 INPUT"1.  ANCHOR DEPTH (FEET)";LL
5410 INPUT"CHANGE ANY DATA?  (ENTER 0=NO, 1=YES)",CAD
5420 IF CAD=0 THEN 5430 ELSE 5400
5430 'OPTION 6
5440 CLS:PRINT"ANCHORED SHEET PILE EMBEDDED IN GRANULAR SUBSOIL, WITH GRANULAR B
ACKFILL":PRINT :PRINT
5450 GOTO 5500
5460 '
5470 '
5480 'OPTION 2
5490 CLS:PRINT "CANTILEVER STEEL SHEET PILE EMBEDDED IN GRANULAR SUBSOIL WITH GR
ANULAR BACKFILL":PRINT :PRINT
5500 'DR$="JOSEPH F. STOCK, JR":DE$="APRIL 8, 1991"
5510 PRINT "FILE NO.:                              ";REC$
5520 PRINT "FIGURE NO.:                            ";EN$
5530 PRINT "DESIGNER:                              ";DR$
5540 PRINT "DATE:                                  ";DE$:PRINT
5550 PRINT "BACKFILL WET DENSITY=                  ";BWD;"  PCF"
5560 PRINT "BACKFILL BUOYANT DENSITY FRACTION=     ";BDF
5570 PRINT "HEIGHT OF BACKFILL=                    ";HHB;"  FEET"
```

```
5580 IF SOT=2 THEN 5670
5590 PRINT "ANCHOR DEPTH=                              ";LL;"  FEET"
5600 'OPTION 6
5610 PRINT :PRINT "ALPHA";TAB(8)"FRICTION";TAB(18)"KP/KA";TAB(26)"DEPTH RATIO";T
AB(39)"NO. OF ";TAB(48)"MOMENT";TAB(58)"ANCHOR"
5620 PRINT TAB(30)"D/H";TAB(39)"TRIALS";TAB(48)"RATIO";TAB(58)"RATIO"
5630 GOTO 5740
5640 PRINT
5650 '
5660 '
5670 'OPTION 2
5680 PRINT :PRINT "ALPHA";TAB(8)"FRICTION";TAB(18)"Kp/Ka";TAB(26)"DEPTH RATIO";T
AB(39)"NO. OF ";TAB(48)"MOMENT"
5690 PRINT TAB(10)"ANGLE";TAB(30)"D/H";TAB(39)"TRIALS";TAB(48)"RATIO"
5700 LPRINT "CANTILEVER STEEL SHEET PILE EMBEDDED IN GRANULAR SUBSOIL WITH GRANU
LAR BACKFILL":LPRINT:LPRINT
5710 LPRINT TAB(70)"OPTION 2":LPRINT TAB(65) "PILE.4 PROGRAM":LPRINT
5720 GOTO 5760
5730 'OPTION 6
5740 LPRINT "ANCHORED SHEET PILE EMBEDDED IN GRANULAR SUBSOIL, WITH GRANULAR BAC
KFILL":LPRINT :LPRINT
5750 LPRINT TAB(70)"OPTION 6":LPRINT TAB(65)"PILE.4 PROGRAM":LPRINT
5760 LPRINT "FILE NO.:                                 ";REC$
5770 LPRINT "FIGURE NO.:                               ";EN$
5780 LPRINT "DESIGNER:                                 ";DR$
5790 LPRINT "DATE:                                     ";DE$:LPRINT
5800 LPRINT "BACKFILL WET DENSITY=                     ";BWD;"  PCF"
5810 LPRINT "BACKFILL BUOYANT DENSITY FRACTION=         ";BDF
5820 LPRINT "HEIGHT OF BACKFILL=                       ";HHB;"  FEET"
5830 IF SOT=6 THEN 5880
5840 'OPTION 2
5850 LPRINT :LPRINT "ALPHA";TAB(8)"FRICTION";TAB(18)"Kp/Ka";TAB(26)"DEPTH RATIO"
;TAB(39)"NO. OF ";TAB(48)"MOMENT"
5860 LPRINT TAB(10)"ANGLE";TAB(30)"D/H";TAB(39)"TRIALS";TAB(48)"RATIO"
5870 GOTO 5920
5880 'OPTION 6
5890 LPRINT "ANCHOR DEPTH=                             ";LL;"  FEET":LPRINT
5900 LPRINT "ALPHA";TAB(8)"FRICTION";TAB(18)"Kp/Ka";TAB(26)"DEPTH RATIO";TAB(39)
"NO. OF ";TAB(48)"MOMENT";TAB(58)"ANCHOR"
5910 LPRINT TAB(30)"D/H";TAB(39)"TRIALS";TAB(48)"RATIO";TAB(58)"RATIO"
5920 GAM=0:'       OPTIONS 2 AND 6
5930 BBD=BDF*BWD:BFA=5:JON=0
5940 '
5950 IF SOT=6 THEN 10660
5960 '
5970 '
5980 '                        OPTION 2 (CONTINUED)
5990 GOSUB 6380
6000 GOTO 6080
6010 GAM=GAM+.25
```

```
6020 BFA=5
6030 GOSUB 6380
6040 IF GAM>1 THEN 4740 ELSE 6080
6050 BFA=BFA+1
6060 GOSUB 6380
6070 '
6080 COSB=COS(SOB*3.14159/180)
6090 COSA=COS(BFA*3.14159/180)
6100 MIKE=SQR(COSB^2-COSA^2)
6110 KA=COSB*((COSB-MIKE)/(COSB+MIKE)):'    REFERENCE 3, EQUATION 11-7
6120 KP=COSB*((COSB+MIKE)/(COSB-MIKE)):'    REFERENCE 3, EQUATION 11-9
6130 'KA=(TAN((45-BFA/2)*3.14159/180))^2 : 'REFERENCE 2, PAGE 317
6140 'KP=(TAN((45+BFA/2)*3.14159/180))^2
6150 GWD=GAM*HHB:'   GROUND WATER DEPTH
6160 PA=KA*(BWD*GWD+BBD*(HHB-GWD))
6170 A=PA/(BBD*(KP-KA))
6180 RC=.5*BWD*GWD^2*KA:'    R1 FORCE
6190 RD=(BWD*GWD*KA)*(HHB-GWD):'     R2 FORCE
6200 RE=PA*.5*A:'     R4 FORCE
6210 N=BBD*(HHB-GWD)*KA
6220 RF=.5*N*(HHB-GWD):'     R3 FORCE
6230 RA=RC+RD+RE+RF
6240 YY=(RC*(A+HHB-GWD*2/3)+RD*(A+.5*(HHB-GWD))+RE*(2*A/3)+RF*(A+(HHB-GWD)*1/3))
/RA
6250 D=D+.05
6260 Y=D-A
6270 PP=BBD*(KP-KA)*Y
6280 MELA=(BWD*GWD+BBD*(HHB-GWD))*KP
6290 MELB=BBD*D*(KP-KA)
6300 PPL=MELA+MELB
6310 ZB=(PP*Y-2*RA)/(PP+PPL)
6320 'MM=6*RA*(Y+YY)-PP*Y^2+(PP+PPL)*ZB^2
6330 C=PP/Y
6340 MM=Y^3-2*RA*Y^2/PPL-6*RA*((1/C)+YY/PPL)*Y-(2*RA/(C*PPL))*(3*PPL*YY+2*RA):'
     DEVIVATION 6
6350 '
6360 '
6370 GOTO 6490
6380 IF BFA<=10 THEN 6390 ELSE 6400
6390 D=4*HHB:RETURN
6400 IF BFA<=15 THEN 6410 ELSE 6420
6410 D=2*HHB:RETURN
6420 IF BFA<=25 THEN 6430 ELSE 6440
6430 D=1.1*HHB:RETURN
6440 IF BFA<=35 THEN 6450 ELSE 6460
6450 D=.6*HHB:RETURN
6460 IF BFA <=45 THEN 6470 ELSE 6480
6470 D=.3*HHB:RETURN
6480 D=.1*HHB:RETURN
6490 '
```

```
6500 JON=JON+1
6510 IF MM>0 THEN 6600
6520 IF JON>9000 THEN 6540
6530 GOTO 6250
6540 KPKA=KP/KA:KPKA=INT(100*(KPKA+.005))/100
6550 PRINT GAM;TAB(9)BFA;TAB(18)KPKA;TAB(30)"--";TAB(40)JON
6560 LPRINT GAM;TAB(9)BFA;TAB(18)KPKA;TAB(30)"--";TAB(40)JON
6570 JON=0
6580 GOSUB 11400
6590 GOTO 6050
6600 KPKA=KP/KA:'    COEFFICIENT OF PASSIVE AND ACTIVE PRESSURE RATIOS
6610 XDIST=SQR(2*RA/(BBD*(KP-KA)))
6620 MMAX=RA*(YY+((2/3)*XDIST))
6630 '
6640 MRATIO=MMAX/(BBD*KA*HHB^3)
6650 MRATIO=INT(1000*(MRATIO+.0005))/1000
6660 DRA=D/HHB:'    DEPTH RATIO
6670 KPKA=INT(1000*(KPKA+.0005))/1000
6680 DRA=INT(1000*(DRA+.0005))/1000
6690 PRINT GAM;TAB(9)BFA;TAB(18)KPKA;TAB(29)DRA;TAB(40)JON;TAB(48)MRATIO
6700 LPRINT GAM;TAB(9)BFA;TAB(18)KPKA;TAB(29)DRA;TAB(40)JON;TAB(48)MRATIO
6710 JON=0
6720 GOSUB 11400
6730 IF BFA<50 THEN 6050 ELSE 6010
6740 '
6750 '
6760 '
6770 '                              OPTIONS 4 AND 8
6780 CLS
6790 INPUT"FILE NO.";REC$
6800 INPUT "FIGURE NO.";EN$
6810 INPUT "DESIGNER";DR$
6820 INPUT "DATE";DE$
6830 INPUT "1.  BACKFILL WET DENSITY (PCF)";BWD
6840 INPUT "2.  BACKFILL BOYANT DENSITY FRACTION (EXAMPLE: 0.5 OF WET DENSITY)";
BDF
6850 INPUT "3.  HEIGHT OF BACKFILL (FEET)";HHB
6860 INPUT "CHANGE ANY DATA?  (ENTER 0=NO, 1=YES)",CAD
6870 IF CAD=0 THEN 6960
6880 INPUT "WHICH LINE TO BE REVISED";WLT
6890 IF WLT=1 THEN 6900 ELSE 6910
6900 INPUT BWD
6910 IF WLT=2 THEN 6920 ELSE 6930
6920 INPUT BDF
6930 IF WLT=3 THEN 6940 ELSE 6860
6940 INPUT HHB
6950 '
6960 BFA=30:'###########################
6970 'DR$="JOSEPH F. STOCK, JR":DE$="APRIL 8, 1991"
6980 IF SOT=4 THEN 7050
```

```
6990 INPUT"1.  ANCHOR DEPTH (FEET)";LL
7000 INPUT"CHANGE ANY DATA?  (ENTER 0=NO, 1=YES)",CAD
7010 IF CAD=0 THEN 7020 ELSE 6990
7020 'OPTION 8
7030 CLS:PRINT"ANCHORED SHEET PILE EMBEDDED IN COHESIVE SUBSOIL, WITH GRANULAR B
ACKFILL":PRINT :PRINT
7040 GOTO 7070
7050 'OPTION 4
7060 CLS:PRINT "CANTILEVER STEEL SHEET PILE EMBEDDED IN COHESIVE SUBSOIL WITH GR
ANULAR BACKFILL":PRINT :PRINT
7070 PRINT "FILE NO.:                              ";REC$
7080 PRINT "FIGURE NO.:                            ";EN$
7090 PRINT "DESIGNER:                              ";DR$
7100 PRINT "DATE:                                  ";DE$:PRINT
7110 PRINT "BACKFILL ASSUMED FRICTION ANGLE=    ";BFA;"  DEGREES"
7120 PRINT "BACKFILL WET DENSITY=                  ";BWD;"  PCF"
7130 PRINT "BACKFILL BUOYANT DENSITY FRACTION=   ";BDF
7140 PRINT "HEIGHT OF BACKFILL=                    ";HHB;"  FEET"
7150 '
7160 IF SOT=4 THEN 7220
7170 'OPTION 8
7180 PRINT "ANCHOR DEPTH=                          ";LL;"  FEET"
7190 PRINT :PRINT "BACKF";TAB(8)"COHESION";TAB(27)"(2qu-q)/";TAB(36)"DEPTH RATIO
";TAB(49)"NO. OF ";TAB(58)"MOMENT";TAB(68)"ANCHOR"
7200 PRINT "ALPHA";TAB(10)"(PSF)";TAB(27)"BBD*Ka*H";TAB(40)"D/H";TAB(49)"TRIALS"
;TAB(58)"RATIO";TAB(68)"RATIO":PRINT
7210 GOTO 7300
7220 'OPTION 4
7230 PRINT TAB(9)"SUBSOIL"
7240 PRINT "BACKF";TAB(8)"COHESION";TAB(27)"(2qu-q)/";TAB(36)"DEPTH RATIO";TAB(4
9)"NO. OF ";TAB(58)"MOMENT"
7250 PRINT "ALPHA";TAB(10)"(PSF)";TAB(27)"BBD*Ka*H";TAB(40)"D/H";TAB(49)"TRIALS"
;TAB(58)"RATIO":PRINT
7260 LPRINT "CANTILEVER STEEL SHEET PILE EMBEDDED IN COHESIVE SUBSOIL, WITH GRAN
ULAR BACKFILL"
7270 LPRINT:LPRINT
7280 LPRINT TAB(70)"OPTION 4":LPRINT TAB(65)"PILE.4 PROGRAM":LPRINT
7290 GOTO 7320
7300 LPRINT "ANCHORED SHEET PILE EMBEDDED IN COHESIVE SUBSOIL, WITH GRANULAR BAC
KFILL":LPRINT:LPRINT:'          OPTION 8
7310 LPRINT TAB(70)"OPTION 8":LPRINT TAB(65)"PILE.4 PROGRAM":LPRINT
7320 LPRINT "FILE NO.:                              ";REC$
7330 LPRINT "FIGURE NO.:                            ";EN$
7340 LPRINT "DESIGNER:                              ";DR$
7350 LPRINT "DATE:                                  ";DE$:LPRINT
7360 LPRINT "BACKFILL ASSUMED FRICTION ANGLE=    ";BFA;"  DEGREES"
7370 LPRINT "BACKFILL WET DENSITY=                  ";BWD;"  PCF"
7380 LPRINT "BACKFILL BUOYANT DENSITY FRACTION=  ";BDF
7390 LPRINT "HEIGHT OF BACKFILL=                    ";HHB;"  FEET"
7400 '
```

```
7410 IF SOT=4 THEN 7460
7420 LPRINT "ANCHOR DEPTH=                              ";LL;"  FEET"
7430 LPRINT :LPRINT "BACKF";TAB(8)"COHESION";TAB(27)"(2qu-q)/";TAB(36)"DEPTH RAT
IO";TAB(49)"NO. OF ";TAB(58)"MOMENT";TAB(68)"ANCHOR"
7440 LPRINT "ALPHA";TAB(10)"(PSF)";TAB(27)"BBD*Ka*H";TAB(40)"D/H";TAB(49)"TRIALS
";TAB(58)"RATIO"TAB(68)"RATIO":LPRINT
7450 GOTO 7490
7460 LPRINT TAB(9)"SUBSOIL"
7470 LPRINT "BACKF.";TAB(8)"COHESION";TAB(27)"(2qu-q)/";TAB(36)"DEPTH RATIO";TAB
(49)"NO. OF ";TAB(58)"MOMENT"
7480 LPRINT "ALPHA";TAB(10)"(PSF)";TAB(27)"BBD*Ka*H"TAB(40)"D/H";TAB(49)"TRIALS"
;TAB(58)"RATIO":LPRINT
7490 COSB=COS(SOB*3.14159/180)
7500 COSA=COS(BFA*3.14159/180)
7510 MIKE=SQR(COSB^2-COSA^2)
7520 KA=COSB*((COSB-MIKE)/(COSB+MIKE)):'    REFERENCE 3, EQUATION 11-7
7530 KP=COSB*((COSB+MIKE)/(COSB-MIKE)):'    REFERENCE 3, EQUATION 11-9
7540 'KA=(TAN((45-BFA/2)*3.14159/180))^2 : 'REFERENCE 2, PAGE 317
7550 'KP=(TAN((45+BFA/2)*3.14159/180))^2
7560 GAM=0
7570 IF SOT=8 THEN 7580 ELSE 7600
7580 BBD=BDF*BWD:GG=7:JON=0:'          OPTION 8
7590 GOTO 7610
7600 BBD=BDF*BWD:GG=10:JON=0:'         OPTION 4
7610 D=.02*HHB
7620 GOTO 7830
7630 GAM=GAM+.25:'                     OPTIONS 4 AND 8
7640 IF SOT=8 THEN 7650 ELSE 7730
7650 D=.02*HHB:GG=7:'                  OPTION 8
7660 IF GAM>1 THEN 4740 ELSE 7830
7670 IF GG>.5 THEN 7680 ELSE 7690
7680 GG=GG-.2:D=.02*HHB:GOTO 7830
7690 IF GG>.1 THEN 7700 ELSE 7630
7700 GG=GG-.1:D=.02*HHB:GOTO 7830
7710 '
7720 '
7730 D=.02*HHB:GG=10:'                 OPTION 4
7740 IF GAM>1 THEN 4740 ELSE 7830
7750 IF GG>1 THEN 7760 ELSE 7780
7760 GG=GG-.2:D=.02*HHB
7770 GOTO 7830
7780 GG=GG-.1:D=.02*HHB
7790 GOTO 7830
7800 '
7810 '
7820 '
7830 GWD=GAM*HHB:'   GROUND WATER DEPTH
7840 QEFF=(BWD*GWD)+(BBD*(HHB-GWD))
7850 QU=.5*(QEFF+GG*BBD*KA*HHB)
7860 COH=.5*QU
```

```
7870 RC=.5*BWD*GWD^2*KA:'      R1 FORCE
7880 RD=(BWD*GWD*KA)*(HHB-GWD):'      R2 FORCE
7890 N=BBD*(HHB-GWD)*KA:'      OR     N=PA-(BWD*GWD*KA)
7900 RF=.5*N*(HHB-GWD):'      R3 FORCE
7910 RA=RC+RD+RF
7920 YY=(RC*(HHB-GWD*2/3)+RD*.5*(HHB-GWD)+RF*(HHB-GWD)/3)/RA
7930 D=D+.05
7940 IF SOT=8 THEN 8020
7950 '
7960 '            OPTION 4
7970 MM=D^2*(1-(4*COH-QEFF)/(6*COH))+D*2*RA*((((1/(6*COH))-1/(4*COH-QEFF)))-(RA/(
4*COH-QEFF))*(((RA/(6*COH))+2*YY)):'      DERIVATION 4
7980 '
7990 GOTO 8040
8000 '
8010 '            OPTION 8
8020 MM=D^2+2*D*(HHB-LL)-2*(HHB-LL-YY)*RA/(4*COH-QEFF)
8030 '
8040 JON=JON+1:'      OPTIONS 4 AND 8
8050 IF SOT=8 THEN 8080
8060 '
8070 IF MM<0 THEN 7930 ELSE 8090:'    OPTION 4
8080 IF MM<0 THEN 7930 ELSE 8120:'     OPTION 8
8090 XDIST=RA/(4*COH-QEFF):'      OPTION 4
8100 MMAX=RA*(YY+XDIST)-((4*COH-QEFF)*.5*(XDIST^2))
8110 GOTO 8290
8120 '                        OPTION 8
8130 F=RA-D*(4*COH-QEFF)
8140 FRATIO=F/(BBD*KA*HHB^2)
8150 FRATIO=INT(1000*(FRATIO+.0005))/1000
8160 IF GAM<1 THEN 8240
8170 JOE=0:Z=GWD*.5:GOTO 8190
8180 Z=Z+.05
8190 JOE=-F+.5*BWD*Z^2*KA
8200 IF JOE<0 THEN 8180
8210 MMAX=F*(Z-LL)-.5*BWD*Z^2*KA*(Z*.33)
8220 GOTO 8290
8230 '
8240 M=BWD*GWD*KA:JOE=0:Z=GWD:GOTO 8260
8250 Z=Z+.05
8260 JOE=-F+.5*M*GWD+M*(Z-GWD)+.5*KA*BBD*(Z-GWD)^2
8270 IF JOE<0 THEN 8250
8280 MMAX=F*(Z-LL)-.5*BWD*GWD^2*KA*(Z-.67*GWD)-.5*BWD*GWD*KA*(Z-GWD)^2-BBD*KA*(Z
-GWD)^3/6
8290 MRATIO=MMAX/(BBD*KA*HHB^3):'     OPTIONS 4 AND 8
8300 MRATIO=INT(1000*(MRATIO+.0005))/1000
8310 Z=INT(100*(Z+.005))/100
8320 DRA=D/HHB:'    DEPTH RATIO
8330 GG=INT(1000*(GG+.0005))/1000
8340 DRA=INT(1000*(DRA+.0005))/1000
```

```
8350 IF SOT=4 THEN 8420
8360 '        OPTION 8
8370 PRINT GAM;TAB(9)COH;TAB(28)GG;TAB(39)DRA;TAB(50)JON;TAB(58)MRATIO;TAB(66)FR
ATIO;TAB(72)Z
8380 LPRINT GAM;TAB(9)COH;TAB(28)GG;TAB(39)DRA;TAB(50)JON;TAB(58)MRATIO;TAB(66)F
RATIO
8390 GOSUB 11780
8400 JON=0
8410 GOTO 7670
8420 '        OPTION 4
8430 PRINT GAM;TAB(9)COH;TAB(28)GG;TAB(39)DRA;TAB(50)JON;TAB(58)MRATIO
8440 LPRINT GAM;TAB(9)COH;TAB(28)GG;TAB(39)DRA;TAB(50)JON;TAB(58)MRATIO
8450 JON=0
8460 GOSUB 11560
8470 IF GG>=2 THEN 7760
8480 IF GG>=.2 THEN 7780 ELSE 7630
8490 '
8500 '
8510 '
8520 '
8530 '                       OPTIONS 3 AND 7 (CONTINUED)
8540 GOSUB 1350
8550 PRINT :PRINT "INPUT SUBSOIL DATA":PRINT
8560 IF ENG=1 THEN 8580
8570 INPUT "COHESION (PSF)";COH:PRINT:GOTO 8590
8580 INPUT "COHESION (kN/SQ METER)";MCOH:PRINT
8590 INPUT "CHANGE ANY DATA?  (ENTER 0=NO, 1=YES)",CAD
8600 IF CAD=0 THEN 8660
8610 IF ENG=1 THEN 8640
8620 INPUT COH
8630 GOTO 8590
8640 INPUT MCOH
8650 GOTO 8590
8660 IF ENG=0 THEN 8680
8670 COH=MCOH*20.89
8680 QU=2*COH:'  REFERENCE 3, PAGE 58
8690 QEFF=(BWD*GWD)+(BBD*(HHB-GWD))
8700 GG=(2*QU-QEFF)/(BBD*KA*HHB)
8710 RC=.5*BWD*GWD^2*KA:'     R1 FORCE
8720 RD=(BWD*GWD*KA)*(HHB-GWD):'      R2 FORCE
8730 N=BBD*(HHB-GWD)*KA:'     OR      N=PA-(BWD*GWD*KA)
8740 RF=.5*N*(HHB-GWD):'      R3 FORCE
8750 RA=RC+RD+RF
8760 YY=(RC*(HHB-GWD*2/3)+RD*.5*(HHB-GWD)+RF*(HHB-GWD)/3)/RA
8770 IF SOT=7 THEN 8790 ELSE 8840
8780 '
8790 IF ENG=1 THEN 8810:'     OPTION 7
8800 INPUT"ANCHOR DEPTH FROM SURFACE (FEET)";LL:GOTO 8820
8810 INPUT"ANCHOR DEPTH FROM SURFACE (METERS)";MLL
8820 INPUT "CHANGE ANY DATA?  (ENTER 0=NO, 1=YES)",CAD
```

```
8830 IF CAD=1 THEN 8790
8840 IF ENG=1 THEN 8860:'     OPTIONS 3 AND 7
8850 MLL=LL/3.28:CLS:LOCATE 10,20:PRINT "THINKING":GOTO 8870
8860 CLS:LOCATE 10,20:PRINT"THINKING METRIC":LL=MLL*3.28
8870 D=.01*HHB
8880 GOTO 8900
8890 D=D+.05
8900 LOCATE 12,20:PRINT JON
8910 EEE=D^2*(4*COH-QEFF)
8920 IF SOT=7 THEN 8930 ELSE 9000
8930 '
8940 '
8950 '           OPTION 7
8960 MM=D^2+2*D*(HHB-LL)-2*(HHB-LL-YY)*RA/(4*COH-QEFF)
8970 '
8980 GOTO 9080
8990 '
9000 CCC=2*D*RA:'     OPTION 3
9010 DDA=2*RA*YY
9020 DDB=((4*D*COH-D*QEFF)^2-2*D*(4*COH-QEFF)*RA)/(6*COH)
9030 ZB=(D*(4*COH-QEFF)-RA)/(4*COH)
9040 'MM=-2*RA*(D+YY)+D^2*(4*COH-QEFF)-(8*COH/3)*ZB^2
9050 MM=D^2*(1-(4*COH-QEFF)/(6*COH))+D*2*RA*(((1/(6*COH))-1/(4*COH-QEFF)))-(RA/(
4*COH-QEFF))*(((RA/(6*COH))+2*YY)):'      DERIVATION 4
9060 '
9070 '
9080 JON=JON+1:'     OPTIONS 3 AND 7
9090 '
9100 IF SOT=3 THEN 9140
9110 IF MM<0 THEN 8890 ELSE 9220:'     OPTION 7
9120 '
9130 '
9140 IF MM<0 THEN 8890:'          OPTION 3
9150 'GG=(2*QU-QEFF)/(BBD*KA*HHB)
9160 PRINT "GG=";GG
9170 'GG=INT(1000*(GG+.0005))/1000
9180 XDIST=RA/(4*COH-QEFF)
9190 '
9200 MMAX=RA*(YY+XDIST)-((4*COH-QEFF)*.5*(XDIST^2))
9210 GOTO 9420
9220 F=RA-D*(4*COH-QEFF):'    OPTION 7
9230 MF=F*3.28/224.8
9240 FRATIO=F/(BBD*KA*HHB^2)
9250 FRATIO=INT(100*(FRATIO+.005))/100
9260 F=INT(100*(F+.005))/100
9270 MF=INT(100*(MF+.005))/100
9280 IF GAM<1 THEN 9360
9290 BON=0:JOE=0:Z=GWD*.5:GOTO 9310
9300 Z=Z+.05
9310 JOE=-F+.5*BWD*Z^2*KA
```

```
9320 BON=BON+1:LOCATE 14,20:PRINT BON
9330 IF JOE<0 THEN 9300
9340 MMAX=F*(Z-LL)-.5*BWD*Z^2*KA*(Z*.33)
9350 GOTO 9420
9360 BON=0:M=BWD*GWD*KA:JOE=0:Z=GWD:GOTO 9380
9370 Z=Z+.05
9380 JOE=-F+.5*M*GWD+M*(Z-GWD)+.5*KA*BBD*(Z-GWD)^2
9390 BON=BON+1:LOCATE 14,20:PRINT BON
9400 IF JOE<0 THEN 9370
9410 MMAX=F*(Z-LL)-.5*BWD*GWD^2*KA*(Z-.67*GWD)-.5*BWD*GWD*KA*(Z-GWD)^2-BBD*KA*(Z
-GWD)^3/6
9420 MRATIO=MMAX/(BBD*KA*HHB^3):'        OPTIONS 3 AND 7
9430 MRATIO=INT(1000*(MRATIO+.0005))/1000
9440 RA=INT(10*(RA+.05))/10
9450 RC=INT(10*(RC+.05))/10
9460 RD=INT(10*(RD+.05))/10
9470 RF=INT(10*(RF+.05))/10
9480 MMAX=INT(10*(MMAX+.05))/10
9490 GG=INT(10*(GG+.05))/10
9500 DRA=D/HHB:'   DEPTH RATIO
9510 DRA=INT(1000*(DRA+.0005))/1000
9520 GAM=GWD/HHB
9530 IF ENG=1 THEN 9590
9540 MBWD=BWD/6.368
9550 MBBD=BBD/6.368
9560 MCOH=COH/20.89
9570 MHHB=HHB/3.28
9580 MGWD=GWD/3.28
9590 MQEFF=QEFF/20.89
9600 MQU=QU/20.89
9610 MD=D/3.28
9620 MYY=YY/3.28
9630 MZB=ZB/3.28
9640 MMMAX=MMAX/224.8
9650 MRD=RD*3.28/224.8
9660 MRF=RF*3.28/224.8
9670 MRA=RA*3.28/224.8
9680 MRC=RC*3.28/224.8
9690 MXDIST=XDIST/3.28
9700 MBWD=INT(100*(MBWD+.005))/100
9710 BWD=INT(100*(BWD+.005))/100
9720 MBBD=INT(100*(MBBD+.005))/100
9730 BBD=INT(100*(BBD+.005))/100
9740 MCOH=INT(100*(MCOH+.005))/100
9750 MHHB=INT(100*(MHHB+.005))/100
9760 MGWD=INT(100*(MGWD+.005))/100
9770 MQEFF=INT(100*(MQEFF+.005))/100
9780 MQU=INT(100*(MQU+.005))/100
9790 MD=INT(100*(MD+.005))/100
9800 MYY=INT(100*(MYY+.005))/100
```

```
9810 MMMAX=INT(10*(MMMAX+.05))/10
9820 MRC=INT(10*(MRC+.05))/10
9830 MRD=INT(10*(MRD+.05))/10
9840 MRF=INT(10*(MRF+.05))/10
9850 MRA=INT(10*(MRA+.05))/10
9860 MXDIST=INT(100*(MXDIST+.005))/100
9870 XDIST=INT(100*(XDIST+.005))/100
9880 KA=INT(1000*(KA+.0005))/1000
9890 KP=INT(1000*(KP+.0005))/1000
9900 D=INT(100*(D+.005))/100
9910 YY=INT(100*(YY+.005))/100
9920 IF SOT=7 THEN 9930 ELSE 9980
9930 PRINT :PRINT "DEPTH";TAB(22)"CENTROID";TAB(56)"ANCHOR";TAB(67)"MOMENT"
9940 PRINT TAB(3)"D";TAB(12)"Ra";TAB(25)"y";TAB(34)"MM";TAB(59)"F";TAB(68)"Mmax"
9950 PRINT TAB(1)"(FT)";TAB(11)"(LBS)";TAB(24)"(FT)";TAB(57)"(LBS)";TAB(66)"(FT-
LBS)":PRINT
9960 PRINT D;TAB(11)RA;TAB(24)YY;TAB(33)MM;TAB(58)F;TAB(68)MMAX:PRINT:PRINT
9970 GOTO 10020
9980 PRINT :PRINT "DEPTH";TAB(20)"CENTROID";TAB(35)"MOMENT"
9990 PRINT TAB(3)"D";TAB(14)"Ra";TAB(24)"y";TAB(36)"Mmax"
10000 PRINT TAB(1)"(FT)";TAB(13)"(LBS)";TAB(23)"(FT)";TAB(34)"(FT-LBS)":PRINT
10010 PRINT D;TAB(13)RA;TAB(23)YY;TAB(36)MMAX:PRINT :PRINT
10020 INPUT "WANT A PRINT OUT?  (ENTER 0=NO, 1=YES)",WPP
10030 IF WPP=0 THEN 4760 ELSE 10040
10040 GOSUB 4800
10050 LPRINT "MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
MMMMMMMMMMM"
10060 IF SOT=7 THEN 10070 ELSE 10090
10070 LPRINT TAB(45)"INPUT DATA";TAB(70)"OPTION 7":LPRINT TAB(65)"PILE.4 PROGRAM
":LPRINT
10080 GOTO 10100
10090 LPRINT TAB(45)"INPUT DATA";TAB(70)"OPTION 3":LPRINT TAB(65)"PILE.4 PROGRAM
":LPRINT
10100 IF ENG=0 THEN 10120
10110 LPRINT TAB(68)"**":GOTO 10130
10120 LPRINT TAB(46)"**"
10130 LPRINT TAB(33)"ENGLISH UNITS";TAB(55)"METRIC UNITS"
10140 LPRINT "BACKFILL WET DENSITY=            ";BWD;"  PCF";TAB(55)MBWD;"  kN/CME
TER"
10150 LPRINT "BACKFILL BUOYANT DENSITY=        ";BBD;"  PCF";TAB(55)MBBD;"  kN/CME
TER"
10160 LPRINT "BACKFILL FRICTION ANGLE=         ";BFA;"  DEGREES";TAB(55)BFA;"  DEG
REES"
10170 LPRINT "WALL FRICTION ANGLE=             ";BBB;"  DEGREES";TAB(55)BBB;"  DEG
REES"
10180 LPRINT "HEIGHT OF BACKFILL=              ";HHB;"  FEET";TAB(55)MHHB;"  METER
S"
10190 LPRINT "SLOPE OF BACKFILL=               ";SOB;"  DEGREES";TAB(55)SOB"  DEGR
EES"
10200 LPRINT "GROUND WATER DEPTH=              ";GWD;"  FEET";TAB(55)MGWD;"  METER
```

```
S"
10210 LPRINT "SUBSOIL COHESION=                    ";COH;"  PSF";TAB(55)MCOH;"  kN/SME
TER"
10220 IF SOT=7 THEN 10230 ELSE 10240
10230 LPRINT "ANCHOR DEPTH =                       ";LL;"  FEET";TAB(55)MLL;"  METERS"
10240 LPRINT :LPRINT "MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
MMMMMMMMMMMMMMMMMMMM"
10250 LPRINT TAB(45)"OUTPUT DATA":LPRINT
10260 LPRINT "BACKFILL:"
10270 LPRINT "ACTIVE COEFFICIENT,Ka=               ";KA;TAB(55)KA
10280 LPRINT "PASSIVE COEFFICIENT,Kp=              ";KP;TAB(55)KP
10290 LPRINT "ALPHA=                               ";GAM;TAB(55)GAM
10300 LPRINT "EFFECTIVE PRESSURE,q=                ";QEFF"  PSF";TAB(55)MQEFF;"  kN/SM
ETER":LPRINT
10310 LPRINT "SUBSOIL:"
10320 LPRINT "UNCONF. COMPRES. STRENGTH,Qu=  ";QU;"  PSF";TAB(55)MQU;"  kN/SMETE
R":LPRINT
10330 LPRINT "PILE DEPTH,D=                        ";D;"  FEET";TAB(55)MD;"  METERS"
10340 LPRINT "D/H=                                 ";DRA;TAB(55)DRA:LPRINT
10350 IF SOT=7 THEN 10360 ELSE 10380
10360 LPRINT "ANCHOR FORCE, F=                     ";F;"  LBS/FT";TAB(55)MF;"  kN/m"
10370 LPRINT "F/(PHI'*KA*H^2)=                     ";FRATIO;TAB(55)FRATIO:LPRINT
10380 LPRINT "CENTROID,Y=                          ";YY;"  FEET";TAB(55)MYY;"  METERS"
10390 LPRINT "(2qu-QEFF)/(PHI'*Ka*H)=              ";GG;TAB(55)GG
10400 IF SOT=7 THEN 10440
10410 LPRINT "Z=                                   ";ZB;TAB(55)MZB
10420 IF SOT=7 THEN 10440
10430 LPRINT "X DISTANCE=                          ";XDIST;"  FEET";TAB(55)MXDIST;"  M
ETERS":'     OPTION 3
10440 LPRINT "MOMENT,Mmax=                         ";MMAX;"  FT-LBS/FT";TAB(55)MMMAX;"
 kN-m/m":'     OPTIONS 3 AND 7
10450 LPRINT "Mmax/(PHI'*Ka*H^3)=                  ";MRATIO;TAB(55)MRATIO:LPRINT
10460 LPRINT "BACKFILL ACTIVE FORCES:"
10470 LPRINT "   R1=                               ";RC;"  LBS/FT";TAB(55)MRC;"  kN/m"
10480 LPRINT "   R2=                               ";RD;"  LBS/FT";TAB(55)MRD;"  kN/m"
10490 LPRINT "   R3=                               ";RF;"  LBS/FT";TAB(55)MRF;"  kN/m"
10500 LPRINT "   TOTAL,Ra=                         ";RA;"  LBS/FT";TAB(55)MRA;"  kN/m"
10510 LPRINT CHR$(12)
10520 GOTO 10020
10530 '
10540 '
10550 GG=1.5*Y^2*(.5*GWD+(HHB-GWD)+A)
10560 ZZ=Y^3
10570 HH=-3*RA*((HHB+A)-(YY+.5*GWD))/(BBD*(KP-KA))
10580 MM=ZZ+GG+HH
10590 PRINT "ZZ=  ";ZZ;"GG=  ";GG;"HH=  ";HH;"MM=  ";MM
10600 II=-.5*RC*GWD*(XX+GWD/3)
10610 JJ=F*(XX+GWD/2)
10620 KK=-RC*(XX^2)/2
10630 LL=-.5*KA*BBD*(XX^3)/3
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```
10640 MMAX=II+JJ+KK+LL:          'REFERENCE 4, PAGE 292
10650 NN=.5*RC*GWD-F+RC*XX+.5*KA*BBD*XX^2:'        REFERENCE 4, PAGE 286, EQ 6.39
10660 '
10670 '
10680 '                    OPTION 6 (CONTINUED)
10690 GOTO 10730
10700 GAM=GAM+.25
10710 IF GAM>1 THEN 4740 ELSE 10730
10720 BFA=BFA+1:GOTO 10740
10730 BFA=5
10740 D=.2*HHB:JON=0:Y=D-A
10750 GOSUB 2300
10760 GOSUB 11350
10770 N=0 :NN=0
10780 GWD=GAM*HHB
10790 PA=KA*(BWD*GWD+BBD*(HHB-GWD))
10800 A=PA/(BBD*(KP-KA))
10810 '
10820 RC=.5*BWD*GWD^2*KA
10830 M=BWD*GWD*KA
10840 RD=M*(HHB-GWD)
10850 RE=PA*.5*A
10860 N=PA-M
10870 RF=.5*N*(HHB-GWD):'    OR        RF=.5*BBD*KA*(HHB-GWD)^2
10880 RA=RC+RD+RE+RF
10890 MGWD=GWD/3.28
10900 MRC=RC*3.28/224.8
10910 MRD=RD*3.28/224.8
10920 MRF=RF*3.28/224.8
10930 MRA=RA*3.28/224.8
10940 MRE=RE*3.28/224.8
10950 MA=A/3.28
10960 GOTO 10970
10970 YY=(RC*(A+HHB-GWD*2/3)+RD*(A+.5*(HHB-GWD))+RE*(2*A/3)+RF*(A+(HHB-GWD)*1/3)
)/RA
10980 MLL=LL/3.28:GOTO 11000
10990 D=D+.05:Y=D-A
11000 MM=Y^3+1.5*Y^2*(HHB+A-LL)-3*RA*(HHB+A-YY-LL)/(BBD*(KP-KA))
11010 JON=JON+1
11020 IF MM<0 THEN 10990
11030 F=RA-.5*BBD*(KP-KA)*Y^2
11040 MF=F*3.28/224.8
11050 '
11060 MBBD=BBD/6.368:MBWD=BWD/6.368
11070 IF GAM<1 THEN 11160
11080 JOE=0:Z=GWD*.5:GOTO 11100
11090 Z=Z+.05
11100 JOE=-F+.5*BWD*Z^2*KA
11110 '
11120 IF JOE<0 THEN 11090
```

```
11130 MMAX=F*(Z-LL)-.5*BWD*Z^2*KA*(Z*.33)
11140 GOTO 11220
11150 '
11160 JOE=0:Z=GWD:GOTO 11180
11170 Z=Z+.05
11180 JOE=-F+.5*M*GWD+M*(Z-GWD)+.5*KA*BBD*(Z-GWD)^2
11190 '
11200 IF JOE<0 THEN 11170
11210 MMAX=F*(Z-LL)-.5*BWD*GWD^2*KA*(Z-.67*GWD)-.5*BWD*GWD*KA*(Z-GWD)^2-BBD*KA*(
Z-GWD)^3/6
11220 KPKA=KP/KA
11230 DRA=D/HHB
11240 MRATIO=MMAX/(BBD*KA*HHB^3)
11250 FRATIO=F/(BBD*KA*HHB^2)
11260 FRATIO=INT(1000*(FRATIO+.0005))/1000
11270 KPKA=INT(1000*(KPKA+.0005))/1000
11280 MRATIO=INT(1000*(MRATIO+.0005))/1000
11290 DRA=INT(1000*(DRA+.0005))/1000
11300 PRINT GAM;TAB(9)BFA;TAB(18)KPKA;TAB(29)DRA;TAB(40)JON;TAB(48)MRATIO;TAB(58
)FRATIO
11310 LPRINT GAM;TAB(9)BFA;TAB(18)KPKA;TAB(29)DRA;TAB(40)JON;TAB(48)MRATIO;TAB(5
8)FRATIO
11320 GOSUB 11680
11330 JON=0
11340 IF BFA<45 THEN 10720 ELSE 10700
11350 IF BFA<=10 THEN 11360 ELSE 11370
11360 D=1.2*HHB:RETURN
11370 IF BFA<=20 THEN 11380 ELSE 11390
11380 D=.6*HHB:RETURN
11390 D=.1*HHB:RETURN
11400 '
11410 '
11420 '
11430 '
11440 'SAVE DATA, OPTION 2
11450 IF COUNT>0 THEN 11510
11460 OPEN REC$ FOR OUTPUT AS #1
11470 WRITE #1,REC$,EN$,DR$
11480 WRITE #1,"B.W. DENSITY","D. FRACTION","B. HEIGHT","B. SLOPE"
11490 WRITE #1,BWD,BDF,HHB,SOB
11500 WRITE #1,"COUNT","ALPHA","B.F. ANGLE","KP/KA-X","D. RATIO-Y","M. RATIO-Y"
11510 COUNT=COUNT+1
11520 WRITE #1,COUNT,GAM,BFA,KPKA,DRA,MRATIO
11530 RETURN
11540 '
11550 '
11560 'SAVE DATA, OPTION 4
11570 IF COUNT>0 THEN 11630
11580 OPEN REC$ FOR OUTPUT AS #1
11590 WRITE #1,REC$,EN$,DR$
```

```
11600 WRITE #1,"B.F. ANGLE","B.W. DENSITY","B.D. FRACTION","SUB F. ANGLE
IGHT","B. SLOPE"
11610 WRITE #1,BFA,BWD,BDF,BBFA,HHB,SOB
11620 WRITE #1,"COUNT","ALPHA","COHESION","COH RATIO-X","D. RATIO-Y","M. RATIO-Y
"
11630 COUNT=COUNT+1
11640 WRITE #1,COUNT,GAM,COH,GG,DRA,MRATIO
11650 RETURN
11660 '
11670 '
11680 'SAVE DATA, OPTION 6
11690 IF COUNT>0 THEN 11750
11700 OPEN REC$ FOR OUTPUT AS #1
11710 WRITE #1,REC$,EN$,DR$
11720 WRITE #1,"B.W. DENSITY","B.D. FRACTION","B. HEIGHT","B. SLOPE","A. DEPTH"
11730 WRITE #1,BWD,BDF,HHB,SOB,LL
11740 WRITE #1,"COUNT","ALPHA","B.F. ANGLE","KP/KA-X","D. RATIO-Y","M. RATIO-Y'"
,"A. RATIO-Y''"
11750 COUNT=COUNT+1
11760 WRITE #1,COUNT,GAM,BFA,KPKA,DRA,MRATIO,FRATIO
11770 RETURN
11780 '
11790 '
11800 '
11810 'SAVE DATA, OPTION 8
11820 IF COUNT>0 THEN 11880
11830 OPEN REC$ FOR OUTPUT AS #1
11840 WRITE #1,REC$,EN$,DR$
11850 WRITE #1,"B.W. DENSITY","B.D. FRACTION","B. HEIGHT","B. SLOPE","A. DEPTH"
11860 WRITE #1,BWD,BDF,HHB,SOB,LL
11870 WRITE #1,"COUNT","ALPHA","COHESION","COH RATIO-X","D. RATIO-Y","M. RATIO-Y
'","A. RATIO-Y''"
11880 COUNT=COUNT+1
11890 WRITE #1,COUNT,GAM,COH,GG,DRA,MRATIO,FRATIO
11900 RETURN
```

APPENDIX B

EXAMPLE PROBLEMS
OPTIONS 1, 3, 5 AND 7

CANTILEVER SHEET PILE EMBEDDED IN GRANULAR SUBSOIL, WITH GRANULAR BACKFILL 1

FILE NO.: SHEET 1 OF 6

TEST NO. 1
PROBLEM 13-6A PAGE 514
BOWLE'S TEXT

DESIGNER: JFS
DATE: NOVEMBER 1991

MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

INPUT DATA OPTION 1
PILE.4 PROGRAM

**

	ENGLISH UNITS	METRIC UNITS
BACKFILL WET DENSITY=	105 PCF	16.49 kN/CMETER
BACKFILL BUOYANT DENSITY=	60.1 PCF	9.439999 kN/CMETER
BACKFILL FRICTION ANGLE=	30 DEGREES	30 DEGREES
WALL FRICTION ANGLE=	17 DEGREES	17 DEGREES
HEIGHT OF BACKFILL=	25 FEET	7.62 METERS
SLOPE OF BACKFILL=	0 DEGREES	0 DEGREES
GROUND WATER DEPTH=	10 FEET	3.05 METERS
UNIFORM SURCHARGE LOAD=	0 PSF	0 kN/SMETER

MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

OUTPUT DATA

	ENGLISH UNITS	METRIC UNITS
BACKFILL:		
ACTIVE COEFFICIENT,Ka=	.299	.299
PASSIVE COEFFICIENT,Kp=	5.385	5.385
Kp/Ka=	17.98	17.98
ALPHA=	.4	.4
PILE DEPTH,D=	20.1 FEET	6.13 METERS
D/H=	.8	.8
CENTROID,Y=	10.25 FEET	3.12 METERS
z=	3.75 FEET	1.14 METERS
DISTANCE TO PIVOT POINT,a=	1.91 FEET	.58 METERS
Pa=	584.36 PSF	27.97 kN/SMETER
Pp=	5559.1 PSF	266.11 kN/SMETER
Pp'=	16652.2 PSF	797.14 kN/SMETER
X DISTANCE=	7.62 FEET	2.32 METERS
MOMENT,Mmax=	135982.2 FT-LBS/FT	604.9 kN-m/m
Mmax/(PHI'*Ka*H^3)=	.48	.48
BACKFILL ACTIVE FORCES:		
R1=	1572.1 LBS/FT	22.94 kN/m
R2=	4716.2 LBS/FT	68.81 kN/m
R3=	2024.6 LBS/FT	29.54 kN/m
R4=	558.6 LBS/FT	8.15 kN/m
TOTAL,Ra=	8871.401 LBS/FT	129.44 kN/m

CANTILEVER SHEET PILE EMBEDDED IN GRANULAR SUBSOIL, WITH GRANULAR BACKFILL 2

FILE NO.: SHEET 2 OF 6

TEST NO. 2
PROBLEM 13-6D PAGE 514
BOWLE'S TEXT

DESIGNER: JFS
DATE: NOVEMBER 1991

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INPUT DATA

OPTION 1
PILE.4 PROGRAM

**

	ENGLISH UNITS	METRIC UNITS
BACKFILL WET DENSITY=	110.17 PCF	17.3 kN/CMETER
BACKFILL BUOYANT DENSITY=	60.43 PCF	9.49 kN/CMETER
BACKFILL FRICTION ANGLE=	33 DEGREES	33 DEGREES
WALL FRICTION ANGLE=	17 DEGREES	17 DEGREES
HEIGHT OF BACKFILL=	24.6 FEET	7.5 METERS
SLOPE OF BACKFILL=	0 DEGREES	0 DEGREES
GROUND WATER DEPTH=	11.48 FEET	3.5 METERS
UNIFORM SURCHARGE LOAD=	0 PSF	0 kN/SMETER

MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

OUTPUT DATA

	ENGLISH UNITS	METRIC UNITS
BACKFILL:		
ACTIVE COEFFICIENT,Ka=	.267	.267
PASSIVE COEFFICIENT,Kp=	6.382	6.382
Kp/Ka=	23.92	23.92
ALPHA=	.47	.47
PILE DEPTH,D=	17.42 FEET	5.31 METERS
D/H=	.71	.71
CENTROID,Y=	9.79 FEET	2.98 METERS
z=	3.05 FEET	.93 METERS
DISTANCE TO PIVOT POINT,a=	1.49 FEET	.45 METERS
Pa=	548.86 PSF	26.27 kN/SMETER
Pp=	5888.7 PSF	281.89 kN/SMETER
Pp'=	19568.7 PSF	936.75 kN/SMETER
X DISTANCE=	6.64 FEET	2.03 METERS
MOMENT,Mmax=	115968.8 FT-LBS/FT	515.88 kN-m/m
Mmax/(PHI'*Ka*H^3)=	.48	.48
BACKFILL ACTIVE FORCES:		
R1=	1936.4 LBS/FT	28.25 kN/m
R2=	4426.2 LBS/FT	64.58 kN/m
R3=	1387.4 LBS/FT	20.24 kN/m
R4=	407.6 LBS/FT	5.95 kN/m
TOTAL,Ra=	8157.6 LBS/FT	119.03 kN/m

FILE NO.: SHEET 3 OF 6

TEST NO. 3
EXAMPLE 13-1 PAGE 484
BOWLE'S TEXT

DESIGNER: JFS
DATE: NOVEMBER 1991

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INPUT DATA — OPTION 1
PILE.4 PROGRAM

**

	ENGLISH UNITS	METRIC UNITS
BACKFILL WET DENSITY=	110 PCF	17.27 kN/CMETER
BACKFILL BUOYANT DENSITY=	60 PCF	9.42 kN/CMETER
BACKFILL FRICTION ANGLE=	30 DEGREES	30 DEGREES
WALL FRICTION ANGLE=	17 DEGREES	17 DEGREES
HEIGHT OF BACKFILL=	20 FEET	6.1 METERS
SLOPE OF BACKFILL=	0 DEGREES	0 DEGREES
GROUND WATER DEPTH=	10 FEET	3.05 METERS
UNIFORM SURCHARGE LOAD=	0 PSF	0 kN/SMETER

MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

OUTPUT DATA

	ENGLISH UNITS	METRIC UNITS
BACKFILL:		
ACTIVE COEFFICIENT,Ka=	.299	.299
PASSIVE COEFFICIENT,Kp=	5.385	5.385
Kp/Ka=	17.98	17.98
ALPHA=	.5	.5
PILE DEPTH,D=	16.8 FEET	5.12 METERS
D/H=	.84	.84
CENTROID,Y=	8.24 FEET	2.51 METERS
z=	3.03 FEET	.93 METERS
DISTANCE TO PIVOT POINT,a=	1.67 FEET	.51 METERS
Pa=	509.05 PSF	24.37 kN/SMETER
Pp=	4617.2 PSF	221.02 kN/SMETER
Pp'=	14280.7 PSF	683.62 kN/SMETER
X DISTANCE=	6.41 FEET	1.95 METERS
MOMENT,Mmax=	78392 FT-LBS/FT	348.72 kN-m/m
Mmax/(PHI'*Ka*H^3)=	.55	.55
BACKFILL ACTIVE FORCES:		
R1=	1646.9 LBS/FT	24.03 kN/m
R2=	3293.8 LBS/FT	48.06 kN/m
R3=	898.3 LBS/FT	13.11 kN/m
R4=	424.6 LBS/FT	6.2 kN/m
TOTAL,Ra=	6263.7 LBS/FT	91.39 kN/m

FILE NO.: SHEET 4 OF 6

TEST NO. 4
EXAMPLE 6.1 PAGE 279
DAS'S TEXT

DESIGNER: JFS
DATE: NOVEMBER 1991

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INPUT DATA — OPTION 1 — PILE.4 PROGRAM

	ENGLISH UNITS	METRIC UNITS **
BACKFILL WET DENSITY=	101.25 PCF	15.9 kN/CMETER
BACKFILL BUOYANT DENSITY=	60.62 PCF	9.520001 kN/CMETER
BACKFILL FRICTION ANGLE=	32 DEGREES	32 DEGREES
WALL FRICTION ANGLE=	0 DEGREES	0 DEGREES
HEIGHT OF BACKFILL=	16.4 FEET	5 METERS
SLOPE OF BACKFILL=	0 DEGREES	0 DEGREES
GROUND WATER DEPTH=	6.56 FEET	2 METERS
UNIFORM SURCHARGE LOAD=	0 PSF	0 kN/SMETER

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OUTPUT DATA

	ENGLISH UNITS	METRIC UNITS
BACKFILL:		
ACTIVE COEFFICIENT,Ka=	.307	.307
PASSIVE COEFFICIENT,Kp=	3.255	3.255
Kp/Ka=	10.59	10.59
ALPHA=	.4	.4
PILE DEPTH,D=	17.78 FEET	5.42 METERS
D/H=	1.08	1.08
CENTROID,Y=	7.32 FEET	2.23 METERS
z=	3.53 FEET	1.08 METERS
DISTANCE TO PIVOT POINT,a=	2.17 FEET	.66 METERS
Pa=	387.37 PSF	18.54 kN/SMETER
Pp=	2789.5 PSF	133.53 kN/SMETER
Pp'=	7280.1 PSF	348.49 kN/SMETER
X DISTANCE=	6.69 FEET	2.04 METERS
MOMENT,Mmax=	47094.6 FT-LBS/FT	209.5 kN-m/m
Mmax/(PHI'*Ka*H^3)=	.57	.57
BACKFILL ACTIVE FORCES:		
R1=	669.4 LBS/FT	9.770001 kN/m
R2=	2008.2 LBS/FT	29.3 kN/m
R3=	901.8 LBS/FT	13.16 kN/m
R4=	419.9 LBS/FT	6.13 kN/m
TOTAL,Ra=	3999.3 LBS/FT	58.35 kN/m

FILE NO.: SHEET 5 OF 6

TEST NO. 5
PROBLEM 6.1 PAGE 303
DAS'S TEXT

DESIGNER: JFS
DATE: NOVEMBER 1991

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INPUT DATA OPTION 1
PILE.4 PROGRAM

**

	ENGLISH UNITS	METRIC UNITS
BACKFILL WET DENSITY=	100 PCF	15.7 kN/CMETER
BACKFILL BUOYANT DENSITY=	47.6 PCF	7.47 kN/CMETER
BACKFILL FRICTION ANGLE=	35 DEGREES	35 DEGREES
WALL FRICTION ANGLE=	0 DEGREES	0 DEGREES
HEIGHT OF BACKFILL=	23 FEET	7.01 METERS
SLOPE OF BACKFILL=	0 DEGREES	0 DEGREES
GROUND WATER DEPTH=	8 FEET	2.44 METERS
UNIFORM SURCHARGE LOAD=	0 PSF	0 kN/SMETER

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OUTPUT DATA

	ENGLISH UNITS	METRIC UNITS
BACKFILL:		
ACTIVE COEFFICIENT,Ka=	.271	.271
PASSIVE COEFFICIENT,Kp=	3.69	3.69
Kp/Ka=	13.62	13.62
ALPHA=	.35	.35
PILE DEPTH,D=	22.8 FEET	6.95 METERS
D/H=	.99	.99
CENTROID,Y=	10.16 FEET	3.1 METERS
z=	4.35 FEET	1.33 METERS
DISTANCE TO PIVOT POINT,a=	2.52 FEET	.77 METERS
Pa=	410.28 PSF	19.64 kN/SMETER
Pp=	3300.5 PSF	157.99 kN/SMETER
Pp'=	9297.7 PSF	445.08 kN/SMETER
X DISTANCE=	8.649999 FEET	2.64 METERS
MOMENT,Mmax=	96975.6 FT-LBS/FT	431.39 kN-m/m
Mmax/(PHI'*Ka*H^3)=	.62	.62
BACKFILL ACTIVE FORCES:		
R1=	867.2 LBS/FT	12.65 kN/m
R2=	3251.9 LBS/FT	47.45 kN/m
R3=	1451.2 LBS/FT	21.17 kN/m
R4=	517.1 LBS/FT	7.55 kN/m
TOTAL,Ra=	6087.4 LBS/FT	88.82 kN/m

FILE NO.: SHEET 6 OF 6

TEST NO. 6
PROBLEM 6.3 PAGE 304
DAS'S TEXT

DESIGNER: JFS
DATE: NOVEMBER 1991

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INPUT DATA OPTION 1
PILE.4 PROGRAM

**

	ENGLISH UNITS	METRIC UNITS
BACKFILL WET DENSITY=	105 PCF	16.49 kN/CMETER
BACKFILL BUOYANT DENSITY=	61.6 PCF	9.67 kN/CMETER
BACKFILL FRICTION ANGLE=	32 DEGREES	32 DEGREES
WALL FRICTION ANGLE=	0 DEGREES	0 DEGREES
HEIGHT OF BACKFILL=	25 FEET	7.62 METERS
SLOPE OF BACKFILL=	0 DEGREES	0 DEGREES
GROUND WATER DEPTH=	10 FEET	3.05 METERS
UNIFORM SURCHARGE LOAD=	0 PSF	0 kN/SMETER

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OUTPUT DATA

	ENGLISH UNITS	METRIC UNITS
BACKFILL:		
ACTIVE COEFFICIENT,Ka=	.307	.307
PASSIVE COEFFICIENT,Kp=	3.255	3.255
Kp/Ka=	10.59	10.59
ALPHA=	.4	.4
PILE DEPTH,D=	27.3 FEET	8.32 METERS
D/H=	1.09	1.09
CENTROID,Y=	11.2 FEET	3.41 METERS
z=	5.41 FEET	1.65 METERS
DISTANCE TO PIVOT POINT,a=	3.34 FEET	1.02 METERS
Pa=	606.53 PSF	29.03 kN/SMETER
Pp=	4349.9 PSF	208.23 kN/SMETER
Pp'=	11381 PSF	544.81 kN/SMETER
X DISTANCE=	10.28 FEET	3.13 METERS
MOMENT,Mmax=	173203.9 FT-LBS/FT	770.48 kN-m/m
Mmax/(PHI'*Ka*H^3)=	.59	.59
BACKFILL ACTIVE FORCES:		
R1=	1613.1 LBS/FT	23.54 kN/m
R2=	4839.3 LBS/FT	70.61 kN/m
R3=	2129.3 LBS/FT	31.07 kN/m
R4=	1013.1 LBS/FT	14.78 kN/m
TOTAL,Ra=	9594.901 LBS/FT	140 kN/m

FILE NO.: SHEET 1 OF 5

TEST NO. 1
EXAMPLE 13-4A PAGE 488
BOWLE'S TEXT

DESIGNER: JFS
DATE: NOVEMBER 1991

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INPUT DATA OPTION 3
PILE.4 PROGRAM

**

	ENGLISH UNITS	METRIC UNITS
BACKFILL WET DENSITY=	110.17 PCF	17.3 kN/CMETER
BACKFILL BUOYANT DENSITY=	60.5 PCF	9.5 kN/CMETER
BACKFILL FRICTION ANGLE=	30 DEGREES	30 DEGREES
WALL FRICTION ANGLE=	17 DEGREES	17 DEGREES
HEIGHT OF BACKFILL=	19.68 FEET	6 METERS
SLOPE OF BACKFILL=	0 DEGREES	0 DEGREES
GROUND WATER DEPTH=	9.84 FEET	3 METERS
SUBSOIL COHESION=	1201.175 PSF	57.5 kN/SMETER

MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

OUTPUT DATA

BACKFILL:		
ACTIVE COEFFICIENT,Ka=	.299	.299
PASSIVE COEFFICIENT,Kp=	5.385	5.385
ALPHA=	.5	.5
EFFECTIVE PRESSURE,q=	1679.318 PSF	80.39 kN/SMETER
SUBSOIL:		
UNCONF. COMPRES. STRENGTH,Qu=	2402.35 PSF	115 kN/SMETER
PILE DEPTH,D=	8.95 FEET	2.73 METERS
D/H=	.455	.455
CENTROID,Y=	6.98 FEET	2.13 METERS
(2qu-QEFF)/(PHI'*Ka*H)=	8.8	8.8
Z=	4.640056	1.414651
X DISTANCE=	1.81 FEET	.55 METERS
MOMENT,Mmax=	44684.6 FT-LBS/FT	198.8 kN-m/m
Mmax/(PHI'*Ka*H^3)=	.324	.324
BACKFILL ACTIVE FORCES:		
R1=	1597 LBS/FT	23.3 kN/m
R2=	3194.1 LBS/FT	46.6 kN/m
R3=	877 LBS/FT	12.8 kN/m
TOTAL,Ra=	5668.1 LBS/FT	82.7 kN/m

FILE NO.: SHEET 2 OF 5

TEST NO. 2
EXAMPLE 6.2 PAGE 282
DAS'S TEXT

DESIGNER: JFS
DATE: NOVEMBER 1991

MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

INPUT DATA OPTION 3
PILE.4 PROGRAM

**

	ENGLISH UNITS	METRIC UNITS
BACKFILL WET DENSITY=	101.25 PCF	15.9 kN/CMETER
BACKFILL BUOYANT DENSITY=	60.62 PCF	9.520001 kN/CMETER
BACKFILL FRICTION ANGLE=	32 DEGREES	32 DEGREES
WALL FRICTION ANGLE=	0 DEGREES	0 DEGREES
HEIGHT OF BACKFILL=	16.4 FEET	5 METERS
SLOPE OF BACKFILL=	0 DEGREES	0 DEGREES
GROUND WATER DEPTH=	6.56 FEET	2 METERS
SUBSOIL COHESION=	981.8299 PSF	47 kN/SMETER

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OUTPUT DATA

BACKFILL:		
ACTIVE COEFFICIENT,Ka=	.307	.307
PASSIVE COEFFICIENT,Kp=	3.255	3.255
ALPHA=	.4	.4
EFFECTIVE PRESSURE,q=	1260.742 PSF	60.35 kN/SMETER
SUBSOIL:		
UNCONF. COMPRES. STRENGTH,Qu=	1963.66 PSF	94 kN/SMETER
PILE DEPTH,D=	7.01 FEET	2.14 METERS
D/H=	.428	.428
CENTROID,Y=	5.84 FEET	1.78 METERS
(2qu-QEFF)/(PHI'*Ka*H)=	8.7	8.7
Z=	3.85098	1.174079
X DISTANCE=	1.34 FEET	.41 METERS
MOMENT,Mmax=	23291.1 FT-LBS/FT	103.6 kN-m/m
Mmax/(PHI'*Ka*H^3)=	.283	.283
BACKFILL ACTIVE FORCES:		
R1=	669.4 LBS/FT	9.8 kN/m
R2=	2008.2 LBS/FT	29.3 kN/m
R3=	901.8 LBS/FT	13.2 kN/m
TOTAL,Ra=	3579.4 LBS/FT	52.2 kN/m

FILE NO.: SHEET 3 OF 5

TEST NO. 3
PROBLEM 13-8A PAGE 514
BOWLE'S TEXT

DESIGNER: JFS
DATE: NOVEMBER 1991

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INPUT DATA OPTION 3
PILE.4 PROGRAM

**

	ENGLISH UNITS	METRIC UNITS
BACKFILL WET DENSITY=	105 PCF	16.49 kN/CMETER
BACKFILL BUOYANT DENSITY=	60.1 PCF	9.439999 kN/CMETER
BACKFILL FRICTION ANGLE=	30 DEGREES	30 DEGREES
WALL FRICTION ANGLE=	17 DEGREES	17 DEGREES
HEIGHT OF BACKFILL=	25 FEET	7.62 METERS
SLOPE OF BACKFILL=	0 DEGREES	0 DEGREES
GROUND WATER DEPTH=	10 FEET	3.05 METERS
SUBSOIL COHESION=	1200 PSF	57.44 kN/SMETER

MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

OUTPUT DATA

BACKFILL:		
ACTIVE COEFFICIENT,Ka=	.299	.299
PASSIVE COEFFICIENT,Kp=	5.385	5.385
ALPHA=	.4	.4
EFFECTIVE PRESSURE,q=	1951.5 PSF	93.42 kN/SMETER
SUBSOIL:		
UNCONF. COMPRES. STRENGTH,Qu=	2400 PSF	114.89 kN/SMETER
PILE DEPTH,D=	12.95 FEET	3.95 METERS
D/H=	.518	.518
CENTROID,Y=	8.939999 FEET	2.73 METERS
(2qu-QEFF)/(PHI'*Ka*H)=	6.3	6.3
Z=	5.953199	1.815
X DISTANCE=	2.92 FEET	.89 METERS
MOMENT,Mmax=	86444.9 FT-LBS/FT	384.5 kN-m/m
Mmax/(PHI'*Ka*H^3)=	.307	.307
BACKFILL ACTIVE FORCES:		
R1=	1572.1 LBS/FT	22.9 kN/m
R2=	4716.2 LBS/FT	68.8 kN/m
R3=	2024.6 LBS/FT	29.5 kN/m
TOTAL,Ra=	8312.8 LBS/FT	121.3 kN/m

FILE NO.: SHEET 4 OF 5

TEST NO. 4
PROBLEM 13-8D PAGE 514
BOWLE'S TEXT

DESIGNER: JFS
DATE: NOVEMBER 1991

MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

INPUT DATA OPTION 3
PILE.4 PROGRAM

**

	ENGLISH UNITS	METRIC UNITS
BACKFILL WET DENSITY=	110.17 PCF	17.3 kN/CMETER
BACKFILL BUOYANT DENSITY=	60.5 PCF	9.5 kN/CMETER
BACKFILL FRICTION ANGLE=	33 DEGREES	33 DEGREES
WALL FRICTION ANGLE=	17 DEGREES	17 DEGREES
HEIGHT OF BACKFILL=	24.6 FEET	7.5 METERS
SLOPE OF BACKFILL=	0 DEGREES	0 DEGREES
GROUND WATER DEPTH=	11.48 FEET	3.5 METERS
SUBSOIL COHESION=	3342.4 PSF	160 kN/SMETER

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OUTPUT DATA

BACKFILL:		
ACTIVE COEFFICIENT,Ka=	.267	.267
PASSIVE COEFFICIENT,Kp=	6.382	6.382
ALPHA=	.4666667	.4666667
EFFECTIVE PRESSURE,q=	2058.418 PSF	98.54 kN/SMETER
SUBSOIL:		
UNCONF. COMPRES. STRENGTH,Qu=	6684.8 PSF	320 kN/SMETER
PILE DEPTH,D=	6.05 FEET	1.84 METERS
D/H=	.246	.246
CENTROID,Y=	8.76 FEET	2.67 METERS
(2qu-QEFF)/(PHI'*Ka*H)=	28.5	28.5
Z=	4.535363	1.382733
X DISTANCE=	.69 FEET	.21 METERS
MOMENT,Mmax=	70581.9 FT-LBS/FT	314 kN-m/m
Mmax/(PHI'*Ka*H^3)=	.294	.294
BACKFILL ACTIVE FORCES:		
R1=	1936.4 LBS/FT	28.3 kN/m
R2=	4426.2 LBS/FT	64.6 kN/m
R3=	1388.9 LBS/FT	20.3 kN/m
TOTAL,Ra=	7751.5 LBS/FT	113.1 kN/m

FILE NO.: SHEET 5 OF 5

TEST NO. 5
PROBLEM 6.7 PAGE 304
DAS'S TEXT

DESIGNER: JFS
DATE: NOVEMBER 1991

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INPUT DATA — OPTION 3
PILE.4 PROGRAM

**

	ENGLISH UNITS		METRIC UNITS	
BACKFILL WET DENSITY=	99.98001	PCF	15.7	kN/CMETER
BACKFILL BUOYANT DENSITY=	47.76	PCF	7.5	kN/CMETER
BACKFILL FRICTION ANGLE=	30	DEGREES	30	DEGREES
WALL FRICTION ANGLE=	0	DEGREES	0	DEGREES
HEIGHT OF BACKFILL=	22.96	FEET	7	METERS
SLOPE OF BACKFILL=	0	DEGREES	0	DEGREES
GROUND WATER DEPTH=	7.872	FEET	2.4	METERS
SUBSOIL COHESION=	605.81	PSF	29	kN/SMETER

MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

OUTPUT DATA

BACKFILL:				
ACTIVE COEFFICIENT,Ka=	.333		.333	
PASSIVE COEFFICIENT,Kp=	3		3	
ALPHA=	.3428572		.3428572	
EFFECTIVE PRESSURE,q=	1507.627	PSF	72.17	kN/SMETER
SUBSOIL:				
UNCONF. COMPRES. STRENGTH,Qu=	1211.62	PSF	58	kN/SMETER
PILE DEPTH,D=	22.98	FEET	7.01	METERS
D/H=	1.001		1.001	
CENTROID,Y=	8.42	FEET	2.57	METERS
(2qu-QEFF)/(PHI'*Ka*H)=	2.5		2.5	
Z=	5.875398		1.79128	
X DISTANCE=	7.43	FEET	2.27	METERS
MOMENT,Mmax=	82535.5	FT-LBS/FT	367.2	kN-m/m
Mmax/(PHI'*Ka*H^3)=	.428		.428	
BACKFILL ACTIVE FORCES:				
R1=	1032.6	LBS/FT	15.1	kN/m
R2=	3958.2	LBS/FT	57.8	kN/m
R3=	1812.1	LBS/FT	26.4	kN/m
TOTAL,Ra=	6802.9	LBS/FT	99.3	kN/m

FILE NO.: SHEET 1 OF 4

TEST NO. 1
EXAMPLE 13-1 PAGE 359
CERNICA'S TEXT

DESIGNER: JFS
DATE: NOVEMBER 1991

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INPUT DATA — OPTION 5
PILE.4 PROGRAM

**

	ENGLISH UNITS	METRIC UNITS
BACKFILL WET DENSITY=	124.94 PCF	19.62 kN/CMETER
BACKFILL BUOYANT DENSITY=	61.64 PCF	9.68 kN/CMETER
BACKFILL FRICTION ANGLE=	32 DEGREES	32 DEGREES
WALL FRICTION ANGLE=	0 DEGREES	0 DEGREES
HEIGHT OF BACKFILL=	32.8 FEET	10 METERS
SLOPE OF BACKFILL=	0 DEGREES	0 DEGREES
GROUND WATER DEPTH=	13.12 FEET	4 METERS
UNIFORM SURCHARGE LOAD=	0 PSF	0 kN/SMETER
ANCHOR DEPTH =	9.8 FEET	3 METERS

MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

OUTPUT DATA

	ENGLISH UNITS	METRIC UNITS
BACKFILL:		
ACTIVE COEFFICIENT,Ka=	.307	.307
PASSIVE COEFFICIENT,Kp=	3.255	3.255
Kp/Ka=	10.59	10.59
ALPHA=	.4	.4
PILE DEPTH,D=	13.66 FEET	4.16 METERS
D/H=	.42	.42
Z=	26.72 FT	8.15 METERS
ANCHOR FORCE, F=	11905.3 LBS/FT	173.7 kN/m
F/(PHI'*KA*H^2)=	.58	.58
MOMENT,Mmax=	87202.21 FT-LBS/FT	387.91 kN-m/m
Mmax/(PHI'*Ka*H^3)=	.13	.13
BACKFILL ACTIVE FORCES:		
R1=	3304 LBS/FT	48.21 kN/m
R2=	9912.099 LBS/FT	144.63 kN/m
R3=	3667.8 LBS/FT	53.52 kN/m
R4=	2113.9 LBS/FT	30.84 kN/m
TOTAL,Ra=	18997.8 LBS/FT	277.19 kN/m

FILE NO.: SHEET 2 OF 4

TEST NO. 2
EXAMPLE 13-3 PAGE 492
BOWLE'S TEXT

DESIGNER: JFS
DATE: NOVEMBER 1991

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INPUT DATA OPTION 5
PILE.4 PROGRAM

**

	ENGLISH UNITS	METRIC UNITS
BACKFILL WET DENSITY=	105 PCF	16.49 kN/CMETER
BACKFILL BUOYANT DENSITY=	66 PCF	10.36 kN/CMETER
BACKFILL FRICTION ANGLE=	30 DEGREES	30 DEGREES
WALL FRICTION ANGLE=	20 DEGREES	20 DEGREES
HEIGHT OF BACKFILL=	30 FEET	9.149999 METERS
SLOPE OF BACKFILL=	0 DEGREES	0 DEGREES
GROUND WATER DEPTH=	8 FEET	2.44 METERS
UNIFORM SURCHARGE LOAD=	500 PSF	23.93 kN/SMETER
ANCHOR DEPTH =	4 FEET	1.2 METERS

MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

OUTPUT DATA

	ENGLISH UNITS	METRIC UNITS
BACKFILL:		
ACTIVE COEFFICIENT,Ka=	.297	.297
PASSIVE COEFFICIENT,Kp=	6.105	6.105
Kp/Ka=	20.53	20.53
ALPHA=	.27	.27
PILE DEPTH,D=	8.5 FEET	2.59 METERS
D/H=	.28	.28
Z=	21.75 FT	6.63 METERS
ANCHOR FORCE, F=	8909.901 LBS/FT	130 kN/m
F/(PHI'*KA*H^2)=	.5	.5
MOMENT,Mmax=	109666.4 FT-LBS/FT	487.84 kN-m/m
Mmax/(PHI'*Ka*H^3)=	.21	.21
BACKFILL ACTIVE FORCES:		
R1=	2188.2 LBS/FT	31.93 kN/m
R2=	8764.8 LBS/FT	127.89 kN/m
R3=	4748.7 LBS/FT	69.29 kN/m
R4=	898.8 LBS/FT	13.11 kN/m
TOTAL,Ra=	16600.6 LBS/FT	242.21 kN/m

FILE NO.: SHEET 3 OF 4

TEST NO. 3
EXAMPLE 6.3 PAGE 292
DAS'S TEXT

DESIGNER: JFS
DATE: NOVEMBER 1991

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INPUT DATA OPTION 5
PILE.4 PROGRAM

**

	ENGLISH UNITS	METRIC UNITS
BACKFILL WET DENSITY=	101.25 PCF	15.9 kN/CMETER
BACKFILL BUOYANT DENSITY=	60.62 PCF	9.520001 kN/CMETER
BACKFILL FRICTION ANGLE=	32 DEGREES	32 DEGREES
WALL FRICTION ANGLE=	0 DEGREES	0 DEGREES
HEIGHT OF BACKFILL=	16.4 FEET	5 METERS
SLOPE OF BACKFILL=	0 DEGREES	0 DEGREES
GROUND WATER DEPTH=	6.56 FEET	2 METERS
UNIFORM SURCHARGE LOAD=	0 PSF	0 kN/SMETER
ANCHOR DEPTH =	3.3 FEET	1 METERS

MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

OUTPUT DATA

	ENGLISH UNITS	METRIC UNITS
BACKFILL:		
ACTIVE COEFFICIENT,Ka=	.307	.307
PASSIVE COEFFICIENT,Kp=	3.255	3.255
Kp/Ka=	10.59	10.59
ALPHA=	.4	.4
PILE DEPTH,D=	6.63 FEET	2.02 METERS
D/H=	.4	.4
Z=	12.56 FT	3.83 METERS
ANCHOR FORCE, F=	2220.6 LBS/FT	32.4 kN/m
F/(PHI'*KA*H^2)=	.44	.44
MOMENT,Mmax=	10797.9 FT-LBS/FT	48.03 kN-m/m
Mmax/(PHI'*Ka*H^3)=	.13	.13
BACKFILL ACTIVE FORCES:		
R1=	669.4 LBS/FT	9.770001 kN/m
R2=	2008.2 LBS/FT	29.3 kN/m
R3=	901.8 LBS/FT	13.16 kN/m
R4=	419.9 LBS/FT	6.13 kN/m
TOTAL,Ra=	3999.3 LBS/FT	58.35 kN/m

FILE NO.: SHEET 4 OF 4

TEST NO. 4
PROBLEM 6.11 PAGE 304
DAS'S TEXT

DESIGNER: JFS
DATE: NOVEMBER 1991

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INPUT DATA — OPTION 5
PILE.4 PROGRAM

	ENGLISH UNITS	** METRIC UNITS
BACKFILL WET DENSITY=	101.89 PCF	16 kN/CMETER
BACKFILL BUOYANT DENSITY=	61.64 PCF	9.68 kN/CMETER
BACKFILL FRICTION ANGLE=	30 DEGREES	30 DEGREES
WALL FRICTION ANGLE=	0 DEGREES	0 DEGREES
HEIGHT OF BACKFILL=	29.684 FEET	9.05 METERS
SLOPE OF BACKFILL=	0 DEGREES	0 DEGREES
GROUND WATER DEPTH=	10.004 FEET	3.05 METERS
UNIFORM SURCHARGE LOAD=	0 PSF	0 kN/SMETER
ANCHOR DEPTH =	4.9 FEET	1.5 METERS

MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

OUTPUT DATA

	ENGLISH UNITS	METRIC UNITS
BACKFILL:		
ACTIVE COEFFICIENT,Ka=	.333	.333
PASSIVE COEFFICIENT,Kp=	3	3
Kp/Ka=	9	9
ALPHA=	.34	.34
PILE DEPTH,D=	13.29 FEET	4.05 METERS
D/H=	.45	.45
Z=	22.85 FT	6.97 METERS
ANCHOR FORCE, F=	7742.6 LBS/FT	113 kN/m
F/(PHI'*KA*H^2)=	.43	.43
MOMENT,Mmax=	76089.21 FT-LBS/FT	338.48 kN-m/m
Mmax/(PHI'*Ka*H^3)=	.14	.14
BACKFILL ACTIVE FORCES:		
R1=	1699.5 LBS/FT	24.8 kN/m
R2=	6686.5 LBS/FT	97.56 kN/m
R3=	3979 LBS/FT	58.06 kN/m
R4=	1684.3 LBS/FT	24.58 kN/m
TOTAL,Ra=	14049.4 LBS/FT	204.99 kN/m

FILE NO.: SHEET 1 OF 4

TEST NO. 1
EXAMPLE 13-4 PAGE 494
BOWLE'S TEXT

DESIGNER: JFS
DATE: NOVEMBER 1991

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INPUT DATA OPTION 7
PILE.4 PROGRAM

**

	ENGLISH UNITS	METRIC UNITS
BACKFILL WET DENSITY=	105.07 PCF	16.5 kN/CMETER
BACKFILL BUOYANT DENSITY=	66.1 PCF	10.38 kN/CMETER
BACKFILL FRICTION ANGLE=	30 DEGREES	30 DEGREES
WALL FRICTION ANGLE=	20 DEGREES	20 DEGREES
HEIGHT OF BACKFILL=	29.848 FEET	9.100001 METERS
SLOPE OF BACKFILL=	0 DEGREES	0 DEGREES
GROUND WATER DEPTH=	7.872 FEET	2.4 METERS
SUBSOIL COHESION=	1002.72 PSF	48 kN/SMETER
ANCHOR DEPTH =	3.936 FEET	1.2 METERS

MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

OUTPUT DATA

BACKFILL:		
ACTIVE COEFFICIENT,Ka=	.297	.297
PASSIVE COEFFICIENT,Kp=	6.105	6.105
ALPHA=	.2637363	.2637363
EFFECTIVE PRESSURE,q=	2279.737 PSF	109.13 kN/SMETER
SUBSOIL:		
UNCONF. COMPRES. STRENGTH,Qu=	2005.44 PSF	96 kN/SMETER
PILE DEPTH,D=	3.6 FEET	1.1 METERS
D/H=	.121	.121
ANCHOR FORCE, F=	4888.24 LBS/FT	71.32 kN/m
F/(PHI'*KA*H^2)=	.28	.28
CENTROID,Y=	10.61 FEET	3.23 METERS
(2qu-QEFF)/(PHI'*Ka*H)=	3	3
MOMENT,Mmax=	40611.9 FT-LBS/FT	180.7 kN-m/m
Mmax/(PHI'*Ka*H^3)=	.078	.078
BACKFILL ACTIVE FORCES:		
R1=	967.9 LBS/FT	14.1 kN/m
R2=	5404.3 LBS/FT	78.9 kN/m
R3=	4745.5 LBS/FT	69.2 kN/m
TOTAL,Ra=	11117.7 LBS/FT	162.2 kN/m

FILE NO.: SHEET 2 OF 4

TEST NO. 2
PROBLEM 13-12A PAGE 515
BOWLE'S TEXT

DESIGNER: JFS
DATE: NOVEMBER 1991

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INPUT DATA — OPTION 7, PILE.4 PROGRAM

**

	ENGLISH UNITS		METRIC UNITS	
BACKFILL WET DENSITY=	105	PCF	16.49	kN/CMETER
BACKFILL BUOYANT DENSITY=	60.1	PCF	9.439999	kN/CMETER
BACKFILL FRICTION ANGLE=	30	DEGREES	30	DEGREES
WALL FRICTION ANGLE=	17	DEGREES	17	DEGREES
HEIGHT OF BACKFILL=	25	FEET	7.62	METERS
SLOPE OF BACKFILL=	0	DEGREES	0	DEGREES
GROUND WATER DEPTH=	10	FEET	3.05	METERS
SUBSOIL COHESION=	1200	PSF	57.44	kN/SMETER
ANCHOR DEPTH =	5	FEET	1.52439	METERS

MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

OUTPUT DATA

BACKFILL:				
ACTIVE COEFFICIENT,Ka=	.299		.299	
PASSIVE COEFFICIENT,Kp=	5.385		5.385	
ALPHA=	.4		.4	
EFFECTIVE PRESSURE,q=	1951.5	PSF	93.42	kN/SMETER
SUBSOIL:				
UNCONF. COMPRES. STRENGTH,Qu=	2400	PSF	114.89	kN/SMETER
PILE DEPTH,D=	1.6	FEET	.49	METERS
D/H=	.064		.064	
ANCHOR FORCE, F=	3755.21	LBS/FT	54.79	kN/m
F/(PHI'*KA*H^2)=	.33		.33	
CENTROID,Y=	8.939999	FEET	2.73	METERS
(2qu-QEFF)/(PHI'*Ka*H)=	6.3		6.3	
MOMENT,Mmax=	20380.7	FT-LBS/FT	90.7	kN-m/m
Mmax/(PHI'*Ka*H^3)=	.072		.072	
BACKFILL ACTIVE FORCES:				
R1=	1572.1	LBS/FT	22.9	kN/m
R2=	4716.2	LBS/FT	68.8	kN/m
R3=	2024.6	LBS/FT	29.5	kN/m
TOTAL,Ra=	8312.8	LBS/FT	121.3	kN/m

FILE NO.: SHEET 3 OF 4

TEST NO. 3
PROBLEM 13-12D PAGE 515
BOWLE'S TEXT

DESIGNER: JFS
DATE: NOVEMBER 1991

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INPUT DATA OPTION 7
PILE.4 PROGRAM

**

	ENGLISH UNITS	METRIC UNITS
BACKFILL WET DENSITY=	110.17 PCF	17.3 kN/CMETER
BACKFILL BUOYANT DENSITY=	60.43 PCF	9.49 kN/CMETER
BACKFILL FRICTION ANGLE=	33 DEGREES	33 DEGREES
WALL FRICTION ANGLE=	17 DEGREES	17 DEGREES
HEIGHT OF BACKFILL=	24.6 FEET	7.5 METERS
SLOPE OF BACKFILL=	0 DEGREES	0 DEGREES
GROUND WATER DEPTH=	11.48 FEET	3.5 METERS
SUBSOIL COHESION=	3342.4 PSF	160 kN/SMETER
ANCHOR DEPTH =	4.92 FEET	1.5 METERS

MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

OUTPUT DATA

BACKFILL:		
ACTIVE COEFFICIENT,Ka=	.267	.267
PASSIVE COEFFICIENT,Kp=	6.382	6.382
ALPHA=	.4666667	.4666667
EFFECTIVE PRESSURE,q=	2057.582 PSF	98.5 kN/SMETER
SUBSOIL:		
UNCONF. COMPRES. STRENGTH,Qu=	6684.8 PSF	320 kN/SMETER
PILE DEPTH,D=	.4 FEET	.12 METERS
D/H=	.016	.016
ANCHOR FORCE, F=	3270.46 LBS/FT	47.72 kN/m
F/(PHI'*KA*H^2)=	.34	.34
CENTROID,Y=	8.76 FEET	2.67 METERS
(2qu-QEFF)/(PHI'*Ka*H)=	28.5	28.5
MOMENT,Mmax=	16609.5 FT-LBS/FT	73.9 kN-m/m
Mmax/(PHI'*Ka*H^3)=	.069	.069
BACKFILL ACTIVE FORCES:		
R1=	1936.4 LBS/FT	28.3 kN/m
R2=	4426.2 LBS/FT	64.6 kN/m
R3=	1387.4 LBS/FT	20.2 kN/m
TOTAL,Ra=	7750 LBS/FT	113.1 kN/m

FILE NO.: SHEET 4 OF 4

TEST NO. 4
PROBLEM 6.15 PAGE 305
DAS'S TEXT

DESIGNER: JFS
DATE: NOVEMBER 1991

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INPUT DATA — OPTION 7
PILE.4 PROGRAM

**

	ENGLISH UNITS		METRIC UNITS	
BACKFILL WET DENSITY=	101.89	PCF	16	kN/CMETER
BACKFILL BUOYANT DENSITY=	57.57	PCF	9.04	kN/CMETER
BACKFILL FRICTION ANGLE=	32	DEGREES	32	DEGREES
WALL FRICTION ANGLE=	0	DEGREES	0	DEGREES
HEIGHT OF BACKFILL=	26.24	FEET	8	METERS
SLOPE OF BACKFILL=	0	DEGREES	0	DEGREES
GROUND WATER DEPTH=	6.56	FEET	2	METERS
SUBSOIL COHESION=	564.03	PSF	27	kN/SMETER
ANCHOR DEPTH =	3.28	FEET	1	METERS

MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

OUTPUT DATA

BACKFILL:				
ACTIVE COEFFICIENT,Ka=	.307		.307	
PASSIVE COEFFICIENT,Kp=	3.255		3.255	
ALPHA=	.25		.25	
EFFECTIVE PRESSURE,q=	1801.298	PSF	86.23001	kN/SMETER
SUBSOIL:				
UNCONF. COMPRES. STRENGTH,Qu=	1128.06	PSF	54	kN/SMETER
PILE DEPTH,D=	8.859999	FEET	2.7	METERS
D/H=	.338		.338	
ANCHOR FORCE, F=	4109.71	LBS/FT	59.96	kN/m
F/(PHI'*KA*H^2)=	.34		.34	
CENTROID,Y=	9.46	FEET	2.88	METERS
(2qu-QEFF)/(PHI'*Ka*H)=	1		1	
MOMENT,Mmax=	33484.3	FT-LBS/FT	149	kN-m/m
Mmax/(PHI'*Ka*H^3)=	.105		.105	
BACKFILL ACTIVE FORCES:				
R1=	673.6	LBS/FT	9.8	kN/m
R2=	4041.6	LBS/FT	59	kN/m
R3=	3425.3	LBS/FT	50	kN/m
TOTAL,Ra=	8140.5	LBS/FT	118.8	kN/m

APPENDIX C

OPTION 2 GRAPH DATA

CANTILEVER STEEL SHEET PILE EMBEDDED IN GRANULAR SUBSOIL WITH GRANULAR BACKFILL

OPTION 2
PILE.4 PROGRAM

FILE NO.: T1.PRN
FIGURE NO.: 1
DESIGNER: JOSEPH F. STOCK, JR
DATE: APRIL 8, 1991

BACKFILL WET DENSITY= 120 PCF
BACKFILL BOYANT DENSITY FRACTION= .5
HEIGHT OF BACKFILL= 20 FEET

ALPHA	FRICTION ANGLE	Kp/Ka	DEPTH RATIO D/H	NO. OF TRIALS	MOMENT RATIO
0	5	1.418	8.765001	1906	6.483
0	6	1.521	7.218	1287	4.652
0	7	1.632	6.113	845	3.531
0	8	1.751	5.283	513	2.792
0	9	1.879	4.638	255	2.277
0	10	2.017	4.123	49	1.903
0	11	2.166	3.698	679	1.623
0	12	2.326	3.345	538	1.406
0	13	2.498	3.047	419	1.236
0	14	2.684	2.79	316	1.098
0	15	2.885	2.57	228	.986
0	16	3.101	2.375	510	.892
0	17	3.336	2.202	441	.814
0	18	3.589	2.05	380	.748
0	19	3.863	1.912	325	.691
0	20	4.16	1.79	276	.642
0	21	4.482	1.677	231	.599
0	22	4.831	1.577	191	.561
0	23	5.21	1.482	153	.528
0	24	5.623	1.397	119	.498
0	25	6.071	1.32	88	.472
0	26	6.559	1.247	259	.449
0	27	7.091	1.18	232	.427
0	28	7.672	1.117	207	.408
0	29	8.306	1.06	184	.391
0	30	9	1.005	162	.375
0	31	9.76	.955	142	.361
0	32	10.592	.907	123	.347
0	33	11.506	.862	105	.335
0	34	12.511	.82	88	.324
0	35	13.617	.78	72	.314
0	36	14.837	.743	177	.304
0	37	16.183	.708	163	.295
0	38	17.671	.673	149	.287
0	39	19.32	.64	136	.279
0	40	21.15	.61	124	.272
0	41	23.184	.583	113	.265
0	42	25.449	.555	102	.259
0	43	27.976	.528	91	.253
0	44	30.803	.5030001	81	.248
0	45	33.97	.48	72	.243
	46	37.528	.458	143	.238

0	47	41.534	.435	134	.234
0	48	46.056	.415	126	.229
0	49	51.174	.395	118	.225
0	50	56.982	.375	110	.221
.25	5	1.418	10.853	2741	12.192
.25	6	1.521	8.92	1968	8.691
.25	7	1.632	7.543	1417	6.554
.25	8	1.751	6.508	1003	5.149
.25	9	1.879	5.705	682	4.175
.25	10	2.017	5.06	424	3.47
.25	11	2.166	4.535	1014	2.943
.25	12	2.326	4.095	838	2.537
.25	13	2.498	3.725	690	2.217
.25	14	2.684	3.407	563	1.961
.25	15	2.885	3.132	453	1.752
.25	16	3.101	2.89	716	1.579
.25	17	3.336	2.677	631	1.434
.25	18	3.589	2.49	556	1.311
.25	19	3.863	2.32	488	1.206
.25	20	4.16	2.167	427	1.116
.25	21	4.482	2.03	372	1.038
.25	22	4.831	1.905	322	.969
.25	23	5.21	1.79	276	.908
.25	24	5.623	1.685	234	.855
.25	25	6.071	1.59	196	.807
.25	26	6.559	1.5	360	.764
.25	27	7.091	1.417	327	.726
.25	28	7.672	1.342	297	.691
.25	29	8.306	1.27	268	.66
.25	30	9	1.205	242	.631
.25	31	9.76	1.142	217	.605
.25	32	10.592	1.085	194	.582
.25	33	11.506	1.03	172	.56
.25	34	12.511	.977	151	.54
.25	35	13.617	.93	132	.5210001
.25	36	14.837	.885	234	.504
.25	37	16.183	.843	217	.489
.25	38	17.671	.8	200	.474
.25	39	19.32	.763	185	.46
.25	40	21.15	.725	170	.448
.25	41	23.184	.69	156	.436
.25	42	25.449	.658	143	.425
.25	43	27.976	.625	130	.415
.25	44	30.803	.595	118	.405
.25	45	33.97	.568	107	.396
.25	46	37.528	.54	176	.387
.25	47	41.534	.513	165	.379
.25	48	46.056	.488	155	.372
.25	49	51.174	.465	146	.365
.25	50	56.982	.443	137	.358
.5	5	1.418	12.803	3521	19.685
.5	6	1.521	10.493	2597	13.863
.5	7	1.632	8.843001	1937	10.332
.5	8	1.751	7.608	1443	8.028
.5	9	1.879	6.648	1059	6.439
.5	10	2.017	5.88	752	5.297
.5	11	2.166	5.255	1302	4.446
.5	12	2.326	4.733	1093	3.796
.5	13	2.498	4.293	917	3.287
.5	14	2.684	3.918	767	2.881

.5	15	2.885	3.59	636	2.552
.5	16	3.101	3.305	882	2.281
.5	17	3.336	3.055	782	2.056
.5	18	3.589	2.832	693	1.865
.5	19	3.863	2.635	614	1.704
.5	20	4.16	2.455	542	1.565
.5	21	4.482	2.295	478	1.445
.5	22	4.831	2.15	420	1.34
.5	23	5.21	2.015	366	1.249
.5	24	5.623	1.895	318	1.168
.5	25	6.071	1.782	273	1.096
.5	26	6.559	1.68	432	1.032
.5	27	7.091	1.585	394	.975
.5	28	7.672	1.497	359	.924
.5	29	8.306	1.415	326	.877
.5	30	9	1.337	295	.835
.5	31	9.76	1.267	267	.797
.5	32	10.592	1.2	240	.762
.5	33	11.506	1.137	215	.731
.5	34	12.511	1.08	192	.702
.5	35	13.617	1.025	170	.675
.5	36	14.837	.972	269	.65
.5	37	16.183	.925	250	.628
.5	38	17.671	.878	231	.607
.5	39	19.32	.835	214	.587
.5	40	21.15	.795	198	.569
.5	41	23.184	.755	182	.552
.5	42	25.449	.718	167	.537
.5	43	27.976	.683	153	.522
.5	44	30.803	.65	140	.5080001
.5	45	33.97	.618	127	.496
.5	46	37.528	.588	195	.484
.5	47	41.534	.558	183	.473
.5	48	46.056	.53	172	.462
.5	49	51.174	.5030001	161	.452
.5	50	56.982	.478	151	.443
.75	5	1.418	14.673	4269	29.106
.75	6	1.521	11.983	3193	20.23
.75	7	1.632	10.065	2426	14.887
.75	8	1.751	8.63	1852	11.425
.75	9	1.879	7.518	1407	9.055
.75	10	2.017	6.63	1052	7.362
.75	11	2.166	5.905	1562	6.111
.75	12	2.326	5.303	1321	5.161
.75	13	2.498	4.795	1118	4.423
.75	14	2.684	4.363	945	3.838
.75	15	2.885	3.988	795	3.366
.75	16	3.101	3.66	1024	2.981
.75	17	3.336	3.375	910	2.661
.75	18	3.589	3.12	808	2.394
.75	19	3.863	2.892	717	2.168
.75	20	4.16	2.69	636	1.975
.75	21	4.482	2.507	563	1.81
.75	22	4.831	2.342	497	1.666
.75	23	5.21	2.192	437	1.541
.75	24	5.623	2.055	382	1.431
.75	25	6.071	1.93	332	1.334
.75	26	6.559	1.815	486	1.248
.75	27	7.091	1.707	443	1.172
	28	7.672	1.61	404	1.104

.75	29	8.306	1.517	367	1.042
.75	30	9	1.432	333	.987
.75	31	9.76	1.355	302	.937
.75	32	10.592	1.282	273	.892
.75	33	11.506	1.212	245	.85
.75	34	12.511	1.147	219	.813
.75	35	13.617	1.087	195	.778
.75	36	14.837	1.032	293	.747
.75	37	16.183	.977	271	.718
.75	38	17.671	.928	251	.691
.75	39	19.32	.88	232	.666
.75	40	21.15	.835	214	.644
.75	41	23.184	.793	197	.622
.75	42	25.449	.753	181	.603
.75	43	27.976	.715	166	.585
.75	44	30.803	.68	152	.568
.75	45	33.97	.645	138	.552
.75	46	37.528	.613	205	.537
.75	47	41.534	.583	193	.523
.75	48	46.056	.553	181	.51
.75	49	51.174	.525	170	.498
.75	50	56.982	.498	159	.487
1	5	1.418	16.49	4996	40.607
1	6	1.521	13.423	3769	27.861
1	7	1.632	11.238	2895	20.244
1	8	1.751	9.602999	2241	15.344
1	9	1.879	8.338	1735	12.014
1	10	2.017	7.328	1331	9.653
1	11	2.166	6.508	1803	7.92
1	12	2.326	5.825	1530	6.614
1	13	2.498	5.25	1300	5.606
1	14	2.684	4.76	1104	4.813
1	15	2.885	4.34	936	4.178
1	16	3.101	3.973	1149	3.663
1	17	3.336	3.65	1020	3.239
1	18	3.589	3.365	906	2.887
1	19	3.863	3.112	805	2.591
1	20	4.16	2.887	715	2.34
1	21	4.482	2.682	633	2.126
1	22	4.831	2.5	560	1.942
1	23	5.21	2.332	493	1.782
1	24	5.623	2.182	433	1.643
1	25	6.071	2.042	377	1.521
1	26	6.559	1.917	527	1.413
1	27	7.091	1.8	480	1.318
1	28	7.672	1.692	437	1.234
1	29	8.306	1.592	397	1.158
1	30	9	1.502	361	1.091
1	31	9.76	1.415	326	1.03
1	32	10.592	1.337	295	.975
1	33	11.506	1.262	265	.926
1	34	12.511	1.192	237	.881
1	35	13.617	1.127	211	.84
1	36	14.837	1.067	307	.802
1	37	16.183	1.012	285	.768
1	38	17.671	.957	263	.737
1	39	19.32	.908	243	.708
1	40	21.15	.86	224	.681
1	41	23.184	.815	206	.657
	42	25.449	.773	189	.634

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1	43	27.976	.733	173	.613
1	44	30.803	.695	158	.594
1	45	33.97	.66	144	.576
1	46	37.528	.625	210	.559
1	47	41.534	.593	197	.543
1	48	46.056	.563	185	.529
1	49	51.174	.533	173	.515
1	50	56.982	.505	162	.5030001

CANTILEVER STEEL SHEET PILE EMBEDDED IN GRANULAR SUBSOIL WITH GRANULAR BACKFILL

OPTION 2
PILE.4 PROGRAM

FILE NO.: T2.PRN
FIGURE NO.: 2
DESIGNER: JOSEPH F. STOCK, JR
DATE: APRIL 8, 1991

BACKFILL WET DENSITY= 120 PCF
BACKFILL BOYANT DENSITY FRACTION= .4
HEIGHT OF BACKFILL= 20 FEET

ALPHA	FRICTION ANGLE	Kp/Ka	DEPTH RATIO D/H	NO. OF TRIALS	MOMENT RATIO
0	5	1.418	8.765001	1906	6.483
0	6	1.521	7.218	1287	4.652
0	7	1.632	6.113	845	3.531
0	8	1.751	5.283	513	2.792
0	9	1.879	4.638	255	2.277
0	10	2.017	4.123	49	1.903
0	11	2.166	3.698	679	1.623
0	12	2.326	3.345	538	1.406
0	13	2.498	3.047	419	1.236
0	14	2.684	2.79	316	1.098
0	15	2.885	2.57	228	.986
0	16	3.101	2.375	510	.892
0	17	3.336	2.202	441	.814
0	18	3.589	2.05	380	.748
0	19	3.863	1.912	325	.691
0	20	4.16	1.79	276	.642
0	21	4.482	1.677	231	.599
0	22	4.831	1.577	191	.561
0	23	5.21	1.482	153	.528
0	24	5.623	1.397	119	.498
0	25	6.071	1.32	88	.472
0	26	6.559	1.247	259	.449
0	27	7.091	1.18	232	.427
0	28	7.672	1.117	207	.408
0	29	8.306	1.06	184	.391
0	30	9	1.005	162	.375
0	31	9.76	.955	142	.361
0	32	10.592	.907	123	.347
0	33	11.506	.862	105	.335
0	34	12.511	.82	88	.324
0	35	13.617	.78	72	.314
0	36	14.837	.743	177	.304
0	37	16.183	.708	163	.295
0	38	17.671	.673	149	.287
0	39	19.32	.64	136	.279
0	40	21.15	.61	124	.272
0	41	23.184	.583	113	.265
0	42	25.449	.555	102	.259
0	43	27.976	.528	91	.253
0	44	30.803	.5030001	81	.248
0	45	33.97	.48	72	.243
0	46	37.528	458	143	.238
	47	41.534	.435	134	.234

0	48	46.056	.415	126	.229
0	49	51.174	.395	118	.225
0	50	56.982	.375	110	.221
.25	5	1.418	11.875	3150	15.892
.25	6	1.521	9.753	2301	11.286
.25	7	1.632	8.238	1695	8.479999
.25	8	1.751	7.103	1241	6.641
.25	9	1.879	6.218	887	5.367
.25	10	2.017	5.513	605	4.446
.25	11	2.166	4.935	1174	3.758
.25	12	2.326	4.455	982	3.23
.25	13	2.498	4.048	819	2.815
.25	14	2.684	3.7	680	2.483
.25	15	2.885	3.397	559	2.213
.25	16	3.101	3.132	813	1.989
.25	17	3.336	2.9	720	1.802
.25	18	3.589	2.695	638	1.644
.25	19	3.863	2.51	564	1.509
.25	20	4.16	2.342	497	1.393
.25	21	4.482	2.192	437	1.292
.25	22	4.831	2.055	382	1.204
.25	23	5.21	1.932	333	1.127
.25	24	5.623	1.817	287	1.058
.25	25	6.071	1.712	245	.997
.25	26	6.559	1.615	406	.943
.25	27	7.091	1.527	371	.894
.25	28	7.672	1.442	337	.85
.25	29	8.306	1.365	306	.81
.25	30	9	1.295	278	.774
.25	31	9.76	1.227	251	.741
.25	32	10.592	1.165	226	.711
.25	33	11.506	1.105	202	.683
.25	34	12.511	1.05	180	.658
.25	35	13.617	.997	159	.635
.25	36	14.837	.947	259	.613
.25	37	16.183	.9	240	.593
.25	38	17.671	.858	223	.575
.25	39	19.32	.815	206	.558
.25	40	21.15	.775	190	.542
.25	41	23.184	.738	175	.527
.25	42	25.449	.703	161	.513
.25	43	27.976	.668	147	.5
.25	44	30.803	.635	134	.488
.25	45	33.97	.605	122	.477
.25	46	37.528	.575	190	.466
.25	47	41.534	.548	179	.456
.25	48	46.056	.52	168	.447
.25	49	51.174	.495	158	.438
.25	50	56.982	.47	148	.43
.5	5	1.418	14.785	4314	29.996
.5	6	1.521	12.09	3236	20.964
.5	7	1.632	10.17	2468	15.51
.5	8	1.751	8.733	1893	11.965
.5	9	1.879	7.618	1447	9.531
.5	10	2.017	6.728	1091	7.787
.5	11	2.166	6	1600	6.494
.5	12	2.326	5.395	1358	5.509
.5	13	2.498	4.885	1154	4.742
.5	14	2.684	4.448	979	4.132
.5	15	2.885	4.07	828	3.638
.5	16	3.101	3.743	1057	3.234
.5	17	3.336	3.452	941	2.898
.5	18	3.589	3.197	839	2.617
.5	19	3.863	2.967	747	2.378
.5	20	4.16	2.762	665	2.173
[illegible]	21	4.482	2.577	591	1.997

.5	22	4.831	2.41	524	1.844
.5	23	5.21	2.257	463	1.71
.5	24	5.623	2.117	407	1.593
.5	25	6.071	1.99	356	1.489
.5	26	6.559	1.872	509	1.397
.5	27	7.091	1.765	466	1.314
.5	28	7.672	1.665	426	1.24
.5	29	8.306	1.572	389	1.174
.5	30	9	1.485	354	1.114
.5	31	9.76	1.405	322	1.059
.5	32	10.592	1.33	292	1.01
.5	33	11.506	1.26	264	.965
.5	34	12.511	1.192	237	.924
.5	35	13.617	1.132	213	.886
.5	36	14.837	1.072	309	.851
.5	37	16.183	1.017	287	.819
.5	38	17.671	.967	267	.79
.5	39	19.32	.918	247	.762
.5	40	21.15	.873	229	.737
.5	41	23.184	.828	211	.714
.5	42	25.449	.788	195	.692
.5	43	27.976	.748	179	.672
.5	44	30.803	.71	164	.653
.5	45	33.97	.675	150	.635
.5	46	37.528	.64	216	.619
.5	47	41.534	.608	203	.603
.5	48	46.056	.578	191	.589
.5	49	51.174	.548	179	.575
.5	50	56.982	.52	168	.563
.75	5	1.418	17.592	5437	49.512
.75	6	1.521	14.33	4132	34.074
.75	7	1.632	12.008	3203	24.832
.75	8	1.751	10.27	2508	18.875
.75	9	1.879	8.923001	1969	14.819
.75	10	2.017	7.85	1540	11.937
.75	11	2.166	6.973	1989	9.82
.75	12	2.326	6.248	1699	8.22
.75	13	2.498	5.635	1454	6.983
.75	14	2.684	5.113	1245	6.007
.75	15	2.885	4.663	1065	5.225
.75	16	3.101	4.273	1269	4.59
.75	17	3.336	3.928	1131	4.066
.75	18	3.589	3.622	1009	3.629
.75	19	3.863	3.352	901	3.262
.75	20	4.16	3.11	804	2.951
.75	21	4.482	2.892	717	2.684
.75	22	4.831	2.697	639	2.454
.75	23	5.21	2.517	567	2.254
.75	24	5.623	2.355	502	2.08
.75	25	6.071	2.207	443	1.927
.75	26	6.559	2.07	588	1.793
.75	27	7.091	1.945	538	1.673
.75	28	7.672	1.83	492	1.566
.75	29	8.306	1.722	449	1.471
.75	30	9	1.625	410	1.386
.75	31	9.76	1.532	373	1.309
.75	32	10.592	1.447	339	1.239
.75	33	11.506	1.367	307	1.176
.75	34	12.511	1.292	277	1.119
.75	35	13.617	1.222	249	1.067
.75	36	14.837	1.157	343	1.019
.75	37	16.183	1.095	318	.975
.75	38	17.671	1.037	295	.935
.75	39	19.32	.982	273	.898
.75	40	21.15	.932	253	.864
.75	41	23.184	[illegible]	[illegible]	[illegible]

.75	42	25.449	.838	215	.804
75	T2 .43	27.976	.795	198	.777
.75	44	30.803	.753	181	.752
.75	45	33.97	.715	166	.729
.75	46	37.528	.678	231	.707
75	47	41.534	.643	217	.687
.75	48	46.056	.61	204	.668
.75	49	51.174	.578	191	.651
.75	50	56.982	.548	179	.634
1	5	1.418	20.341	6537	75.173
1	6	1.521	16.512	5005	51.019
1	7	1.632	13.785	3914	36.669
1	8	1.751	11.748	3099	27.491
1	9	1.879	10.17	2468	21.292
1	10	2.017	8.915	1966	16.923
1	11	2.166	7.893	2357	13.737
1	12	2.326	7.045	2018	11.35
1	13	2.498	6.333	1733	9.517999
1	14	2.684	5.725	1490	8.086001
1	15	2.885	5.203	1281	6.948
1	16	3.101	4.75	1460	6.029
1	17	3.336	4.353	1301	5.278
1	18	3.589	4	1160	4.658
1	19	3.863	3.69	1036	4.14
1	20	4.16	3.412	925	3.704
1	21	4.482	3.162	825	3.334
1	22	4.831	2.937	735	3.017
1	23	5.21	2.735	654	2.745
1	24	5.623	2.55	580	2.509
1	25	6.071	2.382	513	2.303
1	26	6.559	2.23	652	2.123
1	27	7.091	2.087	595	1.964
1	28	7.672	1.957	543	1.824
1	29	8.306	1.84	496	1.7
1	30	9	1.73	452	1.589
1	31	9.76	1.627	411	1.49
1	32	10.592	1.532	373	1.401
1	33	11.506	1.442	337	1.321
1	34	12.511	1.362	305	1.249
1	35	13.617	1.285	274	1.184
1	36	14.837	1.212	365	1.124
1	37	16.183	1.147	339	1.07
1	38	17.671	1.082	313	1.021
1	39	19.32	1.025	290	.976
1	40	21.15	.97	268	.934
1	41	23.184	.918	247	.896
1	42	25.449	.868	227	.862
1	43	27.976	.823	209	.829
1	44	30.803	.778	191	.8
1	45	33.97	.738	175	.772
1	46	37.528	.698	239	.747
1	47	41.534	.66	224	.723
1	48	46.056	.625	210	.701
1	49	51.174	.593	197	.681
	50	56.982	.56	184	.662

CANTILEVER STEEL SHEET PILE EMBEDDED IN GRANULAR SUBSOIL WITH GRANULAR BACKFILL

OPTION 2
PILE.4 PROGRAM

FILE NO.: T3.PRN
FIGURE NO.: 3
DESIGNER: JOSEPH F. STOCK, JR
DATE: APRIL 8, 1991

BACKFILL WET DENSITY= 120 PCF
BACKFILL BOYANT DENSITY FRACTION= .6
HEIGHT OF BACKFILL= 20 FEET

ALPHA	FRICTION ANGLE	Kp/Ka	DEPTH RATIO D/H	NO. OF TRIALS	MOMENT RATIO
0	5	1.418	8.765001	1906	6.483
0	6	1.521	7.218	1287	4.652
0	7	1.632	6.113	845	3.531
0	8	1.751	5.283	513	2.792
0	9	1.879	4.638	255	2.277
0	10	2.017	4.123	49	1.903
0	11	2.166	3.698	679	1.623
0	12	2.326	3.345	538	1.406
0	13	2.498	3.047	419	1.236
0	14	2.684	2.79	316	1.098
0	15	2.885	2.57	228	.986
0	16	3.101	2.375	510	.892
0	17	3.336	2.202	441	.814
0	18	3.589	2.05	380	.748
0	19	3.863	1.912	325	.691
0	20	4.16	1.79	276	.642
0	21	4.482	1.677	231	.599
0	22	4.831	1.577	191	.561
0	23	5.21	1.482	153	.528
0	24	5.623	1.397	119	.498
0	25	6.071	1.32	88	.472
0	26	6.559	1.247	259	.449
0	27	7.091	1.18	232	.427
0	28	7.672	1.117	207	.408
0	29	8.306	1.06	184	.391
0	30	9	1.005	162	.375
0	31	9.76	.955	142	.361
0	32	10.592	.907	123	.347
0	33	11.506	.862	105	.335
0	34	12.511	.82	88	.324
0	35	13.617	.78	72	.314
0	36	14.837	.743	177	.304
0	37	16.183	.708	163	.295
0	38	17.671	.673	149	.287
0	39	19.32	.64	136	.279
0	40	21.15	.61	124	.272
0	41	23.184	.583	113	.265
0	42	25.449	.555	102	.259
0	43	27.976	.528	91	.253
0	44	30.803	.5030001	81	.248
0	45	33.97	.48	72	.243
0	46	37.528	.458	143	.238
	47	41.534	.435	134	.234

0	48	46.056	.415	126	.229
0	T3. 49	51.174	.395	118	.225
0	50	56.982	.375	110	.221
.25	5	1.418	10.163	2465	10.05
.25	6	1.521	8.36	1744	7.181
.25	7	1.632	7.073	1229	5.428
.25	8	1.751	6.108	843	4.274
.25	9	1.879	5.355	542	3.473
.25	10	2.017	4.755	302	2.893
.25	11	2.166	4.263	905	2.458
.25	12	2.326	3.853	741	2.123
.25	13	2.498	3.505	602	1.859
.25	14	2.684	3.207	483	1.647
25	15	2.885	2.95	380	1.474
25	16	3.101	2.725	650	1.33
.25	17	3.336	2.525	570	1.21
.25	18	3.589	2.347	499	1.109
.25	19	3.863	2.19	436	1.021
.25	20	4.16	2.047	379	.946
.25	21	4.482	1.917	327	.881
.25	22	4.831	1.8	280	.824
.25	23	5.21	1.692	237	.773
.25	24	5.623	1.595	198	.728
25	25	6.071	1.502	161	.689
.25	26	6.559	1.42	328	.653
.25	27	7.091	1.342	297	.621
.25	28	7.672	1.27	268	.592
.25	29	8.306	1.205	242	.566
.25	30	9	1.142	217	.542
.25	31	9.76	1.082	193	.52
.25	32	10.592	1.027	171	.5
.25	33	11.506	.977	151	.482
.25	34	12.511	.93	132	.465
.25	35	13.617	.882	113	.449
.25	36	14.837	.84	216	.435
.25	37	16.183	.8	200	.422
.25	38	17.671	.76	184	.409
.25	39	19.32	.725	170	.398
.25	40	21.15	.69	156	.387
.25	41	23.184	.658	143	.377
.25	42	25.449	.625	130	.368
.25	43	27.976	.595	118	.359
.25	44	30.803	.568	107	.351
.25	45	33.97	.54	96	.344
.25	46	37.528	.515	166	.336
.25	47	41.534	.49	156	.33
.25	48	46.056	.465	146	.323
.25	49	51.174	.443	137	.317
.25	50	56.982	.42	128	.312
.5	5	1.418	11.47	2988	14.273
.5	6	1.521	9.415	2166	10.109
.5	7	1.632	7.948	1579	7.577
.5	8	1.751	6.845	1138	5.919
.5	9	1.879	5.99	796	4.772
.5	10	2.017	5.308	523	3.945
.5	11	2.166	4.748	1099	3.328
.5	12	2.326	4.283	913	2.855
.5	13	2.498	3.89	756	2.483
.5	14	2.684	3.553	621	2.186
.5	15	2.885	3.262	505	1.944
.5	16	3.101	3.007	763	1.745
.5	17	3.336	2.782	673	1.579
.5	18	3.589	2.582	593	1.438
.5	19	3.863	2.405	522	1.318
.5	20	4.16	2.245	458	1.215
	21	4.482	2.1	400	1.126

.5	22	4.831	1.967	347	1.047
.5	23	5.21	1.847	299	.979
.5	24	5.623	1.737	255	.918
.5	25	6.071	1.637	215	.864
.5	26	6.559	1.542	377	.816
.5	27	7.091	1.457	343	.773
.5	28	7.672	1.377	311	.734
.5	29	8.306	1.305	282	.699
.5	30	9	1.235	254	.668
.5	31	9.76	1.17	228	.639
.5	32	10.592	1.11	204	.612
.5	33	11.506	1.052	181	.588
.5	34	12.511	1	160	.566
.5	35	13.617	.95	140	.545
.5	36	14.837	.903	241	.527
.5	37	16.183	.858	223	.509
.5	38	17.671	.815	206	.493
.5	39	19.32	.775	190	.478
.5	40	21.15	.738	175	.464
.5	41	23.184	.703	161	.451
.5	42	25.449	.668	147	.439
.5	43	27.976	.635	134	.428
.5	44	30.803	.605	122	.417
.5	45	33.97	.575	110	.407
.5	46	37.528	.548	179	.398
.5	47	41.534	.52	168	.389
.5	48	46.056	.495	158	.381
.5	49	51.174	.47	148	.374
.5	50	56.982	.448	139	.366
.75	5	1.418	12.718	3487	19.167
.75	6	1.521	10.408	2563	13.434
.75	7	1.632	8.762999	1905	9.968001
.75	8	1.751	7.53	1412	7.711
.75	9	1.879	6.573	1029	6.159
.75	10	2.017	5.808	723	5.046
.75	11	2.166	5.183	1273	4.219
.75	12	2.326	4.665	1066	3.589
.75	13	2.498	4.225	890	3.097
.75	14	2.684	3.85	740	2.706
.75	15	2.885	3.528	611	2.389
.75	16	3.101	3.245	858	2.129
.75	17	3.336	2.995	758	1.912
.75	18	3.589	2.775	670	1.731
.75	19	3.863	2.577	591	1.576
.75	20	4.16	2.402	521	1.444
.75	21	4.482	2.242	457	1.33
.75	22	4.831	2.097	399	1.231
.75	23	5.21	1.967	347	1.144
.75	24	5.623	1.847	299	1.068
.75	25	6.071	1.735	254	1.001
.75	26	6.559	1.635	414	.941
.75	27	7.091	1.542	377	.887
.75	28	7.672	1.455	342	.839
.75	29	8.306	1.375	310	.795
.75	30	9	1.3	280	.756
.75	31	9.76	1.23	252	.721
.75	32	10.592	1.165	226	.688
.75	33	11.506	1.102	201	.659
.75	34	12.511	1.047	179	.632
.75	35	13.617	.992	157	.607
.75	36	14.837	.942	257	.584
.75	37	16.183	.895	238	.563
.75	38	17.671	.85	220	.544
.75	39	19.32	.808	203	.526
.75	40	21.15	.768	187	.509
	41	23.184	[illegible]	172	[illegible]

.75	42	25.449	.693	157	.479
.75	43	27.976	.658	143	.466
.75	44	30.803	.625	130	.454
.75	45	33.97	.595	118	.442
.75	46	37.528	.565	186	.431
.75	47	41.534	.538	175	.421
.75	48	46.056	.51	164	.411
.75	49	51.174	.485	154	.402
.75	50	56.982	.46	144	.394
1	5	1.418	13.92	3968	24.751
1	6	1.521	11.358	2943	17.156
1	7	1.632	9.535	2214	12.592
1	8	1.751	8.17	1668	9.639
1	9	1.879	7.11	1244	7.621
1	10	2.017	6.268	907	6.183
1	11	2.166	5.578	1431	5.121
1	12	2.326	5.008	1203	4.317
1	13	2.498	4.525	1010	3.692
1	14	2.684	4.113	845	3.198
1	15	2.885	3.758	703	2.801
1	16	3.101	3.447	939	2.476
1	17	3.336	3.177	831	2.208
1	18	3.589	2.935	734	1.984
1	19	3.863	2.722	649	1.795
1	20	4.16	2.53	572	1.633
1	21	4.482	2.357	503	1.495
1	22	4.831	2.2	440	1.375
1	23	5.21	2.06	384	1.271
1	24	5.623	1.93	332	1.18
1	25	6.071	1.81	284	1.099
1	26	6.559	1.702	441	1.028
1	27	7.091	1.602	401	.965
1	28	7.672	1.51	364	.909
1	29	8.306	1.422	329	.858
1	30	9	1.345	298	.812
1	31	9.76	1.27	268	.771
1	32	10.592	1.2	240	.734
1	33	11.506	1.137	215	.7
1	34	12.511	1.075	190	.669
1	35	13.617	1.02	168	.641
1	36	14.837	.967	267	.615
1	37	16.183	.918	247	.591
1	38	17.671	.87	228	.569
1	39	19.32	.825	210	.549
1	40	21.15	.783	193	.531
1	41	23.184	.743	177	.513
1	42	25.449	.705	162	.497
1	43	27.976	.67	148	.482
1	44	30.803	.638	135	.469
1	45	33.97	.605	122	.456
1	46	37.528	.575	190	.444
1	47	41.534	.545	178	.433
1	48	46.056	.518	167	.422
1	49	51.174	.49	156	.412
1	50	56.982	.465	146	.403

APPENDIX D

OPTION 4 GRAPH DATA

CANTILEVER STEEL SHEET PILE EMBEDDED IN COHESIVE SUBSOIL. WITH GRANULAR BACKFILL

OPTION 4
PILE.4 PROGRAM

FILE NO.: t4.prn
FIGURE NO.: 4
DESIGNER: JOSEPH F. STOCK, JR
DATE: APRIL 8, 1991

BACKFILL ASSUMED FRICTION ANGLE= 30 DEGREES
BACKFILL WET DENSITY= 120 PCF
BACKFILL BUOYANT DENSITY FRACTION= .5
HEIGHT OF BACKFILL= 20 FEET

BACKF. ALPHA	SUBSOIL COHESION (PSF)	(2qu-q)/ BBD*Ka*H	DEPTH RATIO D/H	NO. OF TRIALS	MOMENT RATIO
0	1300.001	10	.323	121	.179
0	1280.001	9.8	.325	122	.179
0	1260.001	9.600001	.33	124	.18
0	1240.001	9.399999	.333	125	.18
0	1220.001	9.2	.338	127	.18
0	1200.001	9	.34	128	.181
0	1180.001	8.8	.345	130	.181
0	1160.001	8.600001	.348	131	.181
0	1140.001	8.399999	.353	133	.182
0	1120.001	8.2	.358	135	.182
0	1100.001	8	.36	136	.182
0	1080.001	7.8	.365	138	.183
0	1060.001	7.6	.37	140	.183
0	1040.001	7.4	.375	142	.184
0	1020.001	7.2	.383	145	.184
0	1000.001	7	.388	147	.185
0	980.0006	6.8	.393	149	.185
0	960.0007	6.6	.4	152	.186
0	940.0006	6.4	.405	154	.186
0	920.0006	6.2	.413	157	.187
0	900.0006	6	.42	160	.187
0	880.0006	5.8	.428	163	.188
0	860.0006	5.6	.435	166	.189
0	840.0005	5.4	.445	170	.19
0	820.0005	5.2	.455	174	.191
0	800.0005	5	.465	178	.192
0	780.0005	4.8	.475	182	.193
0	760.0005	4.6	.485	186	.194
0	740.0004	4.4	.498	191	.195
0	720.0004	4.2	.513	197	.196
0	700.0004	4	.525	202	.198
0	680.0004	3.8	.543	209	.2
0	660.0004	3.6	.56	216	.201
0	640.0003	3.4	.58	224	.203
0	620.0003	3.2	.6	232	.206
0	600.0003	3	.625	242	.208
0	580.0003	2.8	.653	253	.211
0	560.0003	2.6	.683	265	.215
0	540.0002	2.4	.718	279	.219
	520.0003	2.2	.76	296	.223

0	500.0002	2	.81	[illegible]	[illegible]
0	480.0002	1.8	.87	340	.236
0	470.0002	1.7	.905	354	.24
0	460.0002	1.6	.945	370	.245
0	450.0001	1.5	.99	388	.25
0	440.0001	1.4	1.04	408	.256
0	430.0001	1.3	1.097	431	.263
0	420.0001	1.2	1.165	458	.271
0	410.0001	1.1	1.242	489	.28
0	400.0001	1	1.337	527	.292
0	390.0001	.9	1.452	573	.306
0	380.0001	.8	1.595	630	.323
0	370.0001	.7	1.777	703	.345
0	360.0001	.6	2.02	800	.375
0	350.0001	.5	2.357	935	.417
0	340	.4	2.862	1137	.479
0	330	.3	3.702	1473	.583
0	320	.2	5.375	2142	.792
0	310	.1	10.383	4145	1.417
.25	1375.001	10	.408	155	.289
.25	1355.001	9.8	.413	157	.289
.25	1335.001	9.600001	.418	159	.29
.25	1315.001	9.399999	.423	161	.29
.25	1295.001	9.2	.425	162	.291
.25	1275.001	9	.43	164	.292
.25	1255.001	8.8	.435	166	.292
.25	1235.001	8.600001	.443	169	.293
.25	1215.001	8.399999	.448	171	.294
.25	1195.001	8.2	.453	173	.295
.25	1175.001	8	.46	176	.295
.25	1155.001	7.8	.465	178	.296
.25	1135.001	7.6	.473	181	.297
.25	1115.001	7.4	.478	183	.298
.25	1095.001	7.2	.485	186	.299
25	1075 001	7	.493	189	.3
.25	1055.001	6.8	.5	192	.301
25	1035.001	6.6	.51	196	.302
.25	1015.001	6.4	.518	199	.303
.25	995.0006	6.2	.528	203	.305
.25	975.0006	6	.538	207	.306
.25	955.0006	5.8	.548	211	.308
.25	935.0006	5.6	.558	215	.309
.25	915.0005	5.4	.57	220	.311
.25	895.0005	5.2	.583	225	.313
.25	875.0005	5	.595	230	.315
.25	855.0005	4.8	.61	236	.317
.25	835.0005	4.6	.625	242	.319
.25	815.0004	4.4	.643	249	.322
.25	795.0004	4.2	.66	256	.325
.25	775.0004	4	.68	264	.328
.25	755.0004	3.8	.703	273	.331
.25	735.0004	3.6	.728	283	.335
.25	715.0003	3.4	.753	293	.339
.25	695.0003	3.2	.783	305	.344
.25	675.0003	3	.815	318	.349
.25	655.0003	2.8	.853	333	.355
.25	635.0003	2.6	.898	351	.362
.25	615.0002	2.4	.947	371	.371
25	595.0003	2.2	1.005	394	.38
.25	575.0002	2	1.075	422	.392
25	555.0002	1.8	1.16	456	.407
25	545.0001	1.7	1.21	476	.415
25	535.0001	1.6	1.265	498	.424
25	525.0001	1.5	1.327	523	.435
.25	515.0002	1.4	1.397	551	.448
	505.0001	1.3	1.48	584	.462

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
.25	485.0001	1.1	1.687	667	.498
.25	475.0001	1	1.822	721	.5210001
.25	465.0001	.9	1.985	786	.55
.25	455.0001	.8	2.187	867	.586
.25	445.0001	.7	2.447	971	.632
.25	435.0001	.6	2.795	1110	.694
.25	425.0001	.5	3.277	1303	.78
.25	415	.4	4.003	1593	.909
.25	405	.3	5.205	2074	1.124
.25	395	.2	7.605	3034	1.555
.25	385	.1	14.8	5912	2.846
.5	1450.001	10	.45	172	.351
.5	1430.001	9.8	.455	174	.352
.5	1410.001	9.600001	.46	176	.352
.5	1390.001	9.399999	.465	178	.353
.5	1370.001	9.2	.47	180	.354
.5	1350.001	9	.475	182	.355
.5	1330.001	8.8	.48	184	.356
.5	1310.001	8.600001	.488	187	.357
.5	1290.001	8.399999	.493	189	.358
.5	1270.001	8.2	.5	192	.359
.5	1250.001	8	.5080001	195	.36
.5	1230.001	7.8	.515	198	.362
.5	1210.001	7.6	.523	201	.363
.5	1190.001	7.4	.53	204	.364
.5	1170.001	7.2	.538	207	.366
.5	1150.001	7	.548	211	.367
.5	1130.001	6.8	.555	214	.369
.5	1110.001	6.6	.565	218	.371
.5	1090.001	6.4	.575	222	.372
.5	1070.001	6.2	.585	226	.374
.5	1050.001	6	.598	231	.376
.5	1030.001	5.8	.61	236	.379
.5	1010.001	5.6	.623	241	.381
.5	990.0005	5.4	.635	246	.383
.5	970.0005	5.2	.65	252	.386
.5	950.0005	5	.665	258	.389
.5	930.0005	4.8	.683	265	.392
.5	910.0005	4.6	.7	272	.396
.5	890.0004	4.4	.72	280	.4
.5	870.0004	4.2	.743	289	.404
.5	850.0004	4	.765	298	.408
.5	830.0004	3.8	.79	308	.413
.5	810.0004	3.6	.82	320	.419
.5	790.0003	3.4	.85	332	.425
.5	770.0003	3.2	.885	346	.432
.5	750.0003	3	.925	362	.44
.5	730.0003	2.8	.97	380	.449
.5	710.0003	2.6	1.022	401	.46
.5	690.0002	2.4	1.082	425	.472
.5	670.0003	2.2	1.152	453	.487
.5	650.0002	2	1.235	486	.504
.5	630.0002	1.8	1.337	527	.525
.5	620.0001	1.7	1.395	550	.538
.5	610.0001	1.6	1.462	577	.552
.5	600.0001	1.5	1.537	607	.568
.5	590.0001	1.4	1.622	641	.586
.5	580.0001	1.3	1.722	681	.607
.5	570.0001	1.2	1.837	727	.632
.5	560.0001	1.1	1.972	781	.661
.5	550.0001	1	2.135	846	.695
.5	540.0001	.9	2.332	925	.738
.5	530.0001	.8	2.577	1023	.791
.5	520.0001	.7	2.892	1149	.859
	510.0001	.6	3.315	1318	.951

.5	500.0001	.5	[illegible]	[illegible]	[illegible]
.5	490.0001	.4	4.78	1904	1.27
.5	480.0001	.3	6.243	2489	1.589
.5	470.0001	.2	9.163	3657	2.227
.5	460	.1	17.919	7160	4.141
.75	1525.001	10	.465	178	.378
.75	1505.001	9.8	.47	180	.379
.75	1485.001	9.600001	.475	182	.38
.75	1465.001	9.399999	.48	184	.381
.75	1445.001	9.2	.488	187	.382
.75	1425.001	9	.493	189	.383
.75	1405.001	8.8	.498	191	.384
.75	1385.001	8.600001	.505	194	.385
75	1365.001	8.399999	.513	197	.387
.75	1345.001	8.2	.518	199	.388
.75	1325.001	8	.525	202	.389
.75	1305.001	7.8	.533	205	.391
.75	1285.001	7.6	.543	209	.392
75	1265.001	7.4	.55	212	.394
.75	1245.001	7.2	.56	216	.396
.75	1225.001	7	.568	219	.398
.75	1205.001	6.8	.578	223	.4
.75	1185.001	6.6	.588	227	.402
.75	1165.001	6.4	.6	232	.404
75	1145.001	6.2	.61	236	.406
.75	1125.001	6	.623	241	.409
.75	1105.001	5.8	.635	246	.412
.75	1085.001	5.6	.65	252	.415
.75	1065.001	5.4	.665	258	.418
.75	1045.001	5.2	.68	264	.421
.75	1025.001	5	.698	271	.425
.75	1005.001	4.8	.715	278	.428
.75	985.0005	4.6	.735	286	.433
.75	965.0004	4.4	.755	294	.437
.75	945.0004	4.2	.78	304	.442
.75	925.0004	4	.805	314	.448
.75	905.0004	3.8	.833	325	.454
.75	885.0004	3.6	.863	337	.461
75	865.0003	3.4	.898	351	.469
.75	845.0003	3.2	.935	366	.477
.75	825.0003	3	.98	384	.487
.75	805.0003	2.8	1.027	403	.498
.75	785.0003	2.6	1.085	426	.511
.75	765.0002	2.4	1.15	452	.526
.75	745.0003	2.2	1.227	483	.544
.75	725.0002	2	1.317	519	.565
.75	705.0002	1.8	1.43	564	.591
.75	695.0001	1.7	1.495	590	.607
75	685.0001	1.6	1.567	619	.624
.75	675.0001	1.5	1.65	652	.644
.75	665.0001	1.4	1.745	690	.666
.75	655.0001	1.3	1.855	734	.692
.75	645.0001	1.2	1.98	784	.722
.75	635.0001	1.1	2.13	844	.757
.75	625.0001	1	2.307	915	.8
.75	615.0001	.9	2.525	1002	.852
75	605.0001	.8	2.797	1111	.917
.75	595.0001	.7	3.147	1251	1.001
.75	585.0001	.6	3.61	1436	1.113
75	575.0001	.5	4.26	1696	1.269
.75	565.0001	.4	5.233	2085	1.504
75	555	.3	6.85	2732	1.895
75	545	.2	10.083	4025	2.677
1	535	.1	19.774	7902	5.023
1	1600.001	10	.465	178	.383
	1580.001	9.8	.47	180	.384

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	1540.001	9.399999	.48	184	.387
1	1520.001	9.2	.485	186	.388
1	1500.001	9	.493	189	.389
1	1480.001	8.8	.498	191	.39
1	1460.001	8.600001	.505	194	.391
1	1440.001	8.399999	.513	197	.393
1	1420.001	8.2	.518	199	.394
1	1400.001	8	.525	202	.396
1	1380.001	7.8	.535	206	.397
1	1360.001	7.6	.543	209	.399
1	1340.001	7.4	.55	212	.401
1	1320.001	7.2	.56	216	.403
1	1300.001	7	.57	220	.405
1	1280.001	6.8	.58	224	.407
1	1260.001	6.6	.59	228	.409
1	1240.001	6.4	.6	232	.411
1	1220.001	6.2	.613	237	.414
1	1200.001	6	.625	242	.417
1	1180.001	5.8	.638	247	.42
1	1160.001	5.6	.653	253	.423
1	1140.001	5.4	.668	259	.426
1	1120.001	5.2	.683	265	.429
1	1100.001	5	.7	272	.433
1	1080.001	4.8	.718	279	.437
1	1060.001	4.6	.738	287	.442
1	1040	4.4	.76	296	.447
1	1020	4.2	.785	306	.452
1	1000	4	.81	316	.458
1	980.0004	3.8	.84	328	.465
1	960.0004	3.6	.87	340	.472
1	940.0003	3.4	.905	354	.48
1	920.0003	3.2	.945	370	.49
1	900 0002	3	.99	388	.5
1	880.0002	2.8	1.04	408	.5120001
1	860.0002	2.6	1.097	431	.526
1	840 0002	2.4	1.165	458	.542
1	820.0003	2.2	1.242	489	.561
1	800.0002	2	1.337	527	.583
1	780.0002	1.8	1.452	573	.611
1	770.0001	1.7	1.52	600	.627
1	760.0001	1.6	1.595	630	.646
1	750.0001	1.5	1.68	664	.667
1	740.0001	1.4	1.777	703	.69
1	730.0001	1.3	1.89	748	.718
1	720 0001	1.2	2.02	800	.75
1	710.0001	1.1	2.175	862	.788
1	700.0001	1	2.357	935	.833
1	690.0001	.9	2.582	1025	.889
1	680.0001	.8	2.862	1137	.958
1	670.0001	.7	3.222	1281	1.048
1	660.0001	.6	3.702	1473	1.167
1	650.0001	.5	4.373	1741	1.333
1	640.0001	.4	5.375	2142	1.583
1	630	.3	7.045	2810	2
1	620	.2	10.383	4145	2.833
	610	.1	20.386	8147	5.333

CANTILEVER STEEL SHEET PILE EMBEDDED IN COHESIVE SUBSOIL, WITH GRANULAR BACKFILL

OPTION 4
PILE.4 PROGRAM

FILE NO.: T5.PRN
FIGURE NO.: 5
DESIGNER: JOSEPH F. STOCK, JR
DATE: APRIL 8, 1991

BACKFILL ASSUMED FRICTION ANGLE= 30 DEGREES
BACKFILL WET DENSITY= 120 PCF
BACKFILL BUOYANT DENSITY FRACTION= .4
HEIGHT OF BACKFILL= 20 FEET

BACKF. ALPHA	SUBSOIL COHESION (PSF)	(2qu-q)/ BBD*Ka*H	DEPTH RATIO D/H	NO. OF TRIALS	MOMENT RATIO
0	1040.001	10	.323	121	.179
0	1024.001	9.8	.325	122	.179
0	1008.001	9.600001	.33	124	.18
0	992.0008	9.399999	.333	125	.18
0	976.0007	9.2	.338	127	.18
0	960.0007	9	.34	128	.181
0	944.0008	8.8	.345	130	.181
0	928.0006	8.600001	.348	131	.181
0	912.0007	8.399999	.353	133	.182
0	896.0005	8.2	.358	135	.182
0	880.0006	8	.36	136	.182
0	864.0006	7.8	.365	138	.183
0	848.0006	7.6	.37	140	.183
0	832.0005	7.4	.375	142	.184
0	816.0005	7.2	.383	145	.184
0	800.0006	7	.388	147	.185
0	784.0006	6.8	.393	149	.185
0	768.0006	6.6	.4	152	.186
0	752.0005	6.4	.405	154	.186
0	736.0004	6.2	.413	157	.187
0	720.0005	6	.42	160	.188
0	704.0005	5.8	.428	163	.188
0	688.0005	5.6	.435	166	.189
0	672.0004	5.4	.445	170	.19
0	656.0004	5.2	.455	174	.191
0	640.0004	5	.465	178	.192
0	624.0004	4.8	.475	182	.193
0	608.0004	4.6	.485	186	.194
0	592.0003	4.4	.498	191	.195
0	576.0003	4.2	.513	197	.196
0	560.0003	4	.525	202	.198
0	544.0003	3.8	.543	209	.2
0	528.0003	3.6	.56	216	.201
0	512.0003	3.4	.58	224	.203
0	496.0003	3.2	.6	232	.206
0	480.0003	3	.625	242	.208
0	464.0002	2.8	.653	253	.211
	448.0002	2.6	.683	265	.215

0	432.0002	2.4	.718	279	.219
0	416.0002	2.2	.76	296	.223
0	400.0002	2	.81	316	.229
0	384.0001	1.8	.87	340	.236
0	376.0001	1.7	.905	354	.24
0	368.0001	1.6	.945	370	.245
0	360.0001	1.5	.99	388	.25
0	352.0001	1.4	1.04	408	.256
0	344.0001	1.3	1.097	431	.263
0	336.0001	1.2	1.165	458	.271
0	328.0001	1.1	1.242	489	.28
0	320.0001	1	1.337	527	.292
0	312.0001	.9	1.452	573	.306
0	304.0001	.8	1.595	630	.323
0	296.0001	.7	1.777	703	.345
0	288.0001	.6	2.02	800	.375
0	280	.5	2.357	935	.417
0	272	.4	2.862	1137	.479
0	264	.3	3.702	1473	.583
0	256	.2	5.375	2142	.792
0	248	.1	10.383	4145	1.417
.25	1130.001	10	.445	170	.345
.25	1114.001	9.8	.45	172	.346
.25	1098.001	9.600001	.455	174	.347
.25	1082.001	9.399999	.46	176	.348
.25	1066.001	9.2	.465	178	.348
.25	1050.001	9	.473	181	.349
.25	1034.001	8.8	.478	183	.35
.25	1018.001	8.600001	.483	185	.351
.25	1002.001	8.399999	.49	188	.352
.25	986.0005	8.2	.495	190	.353
.25	970.0006	8	.5030001	193	.354
.25	954.0006	7.8	.51	196	.355
.25	938.0006	7.6	.518	199	.356
.25	922.0005	7.4	.525	202	.358
.25	906.0005	7.2	.533	205	.359
.25	890.0006	7	.54	208	.36
.25	874.0006	6.8	.55	212	.362
.25	858.0006	6.6	.558	215	.363
.25	842.0004	6.4	.568	219	.365
.25	826.0004	6.2	.58	224	.367
.25	810.0005	6	.59	228	.368
.25	794.0005	5.8	.603	233	.37
.25	778.0005	5.6	.615	238	.372
.25	762.0004	5.4	.628	243	.375
.25	746.0004	5.2	.64	248	.377
.25	730.0004	5	.655	254	.38
.25	714.0004	4.8	.673	261	.383
.25	698.0004	4.6	.69	268	.386
.25	682.0003	4.4	.71	276	.389
.25	666.0003	4.2	.73	284	.393
.25	650.0003	4	.753	293	.397
.25	634.0003	3.8	.778	303	.401
.25	618.0003	3.6	.803	313	.406
.25	602.0003	3.4	.835	326	.412
.25	586.0003	3.2	.868	339	.418
.25	570.0003	3	.905	354	.425
.25	554.0003	2.8	.947	371	.434
.25	538.0002	2.6	.997	391	.443
.25	522.0002	2.4	1.055	414	.454

.25	506.0002	2.2	1.12	440	.467
.25	490.0002	2	1.2	472	.483
.25	474.0001	1.8	1.297	511	.502
.25	466.0001	1.7	1.355	534	.513
.25	458.0001	1.6	1.417	559	.526
.25	450.0001	1.5	1.49	588	.54
.25	442.0001	1.4	1.57	620	.556
.25	434.0001	1.3	1.665	658	.575
.25	426.0001	1.2	1.772	701	.597
.25	418.0001	1.1	1.902	753	.623
.25	410.0001	1	2.055	814	.654
.25	402.0001	.9	2.242	889	.692
.25	394.0001	.8	2.477	983	.74
.25	386.0001	.7	2.775	1102	.801
.25	378.0001	.6	3.175	1262	.883
.25	370	.5	3.73	1484	.997
.25	362	.4	4.563	1817	1.168
.25	354	.3	5.948	2371	1.454
.25	346	.2	8.713	3477	2.026
.25	338	.1	17	6792	3.74
.5	1220.001	10	.5030001	193	.442
.5	1204.001	9.8	.51	196	.443
.5	1188.001	9.600001	.515	198	.444
.5	1172.001	9.399999	.523	201	.445
.5	1156.001	9.2	.528	203	.447
.5	1140.001	9	.535	206	.448
.5	1124.001	8.8	.54	208	.45
.5	1108.001	8.600001	.548	211	.451
.5	1092.001	8.399999	.555	214	.453
.5	1076.001	8.2	.563	217	.454
.5	1060.001	8	.57	220	.456
.5	1044.001	7.8	.58	224	.458
.5	1028.001	7.6	.588	227	.46
.5	1012.001	7.4	.598	231	.462
.5	996.0005	7.2	.608	235	.464
.5	980.0006	7	.618	239	.466
.5	964.0006	6.8	.628	243	.468
.5	948.0006	6.6	.638	247	.471
.5	932.0004	6.4	.65	252	.474
.5	916.0004	6.2	.663	257	.476
.5	900.0005	6	.678	263	.479
.5	884.0005	5.8	.69	268	.483
.5	868.0005	5.6	.705	274	.486
.5	852.0004	5.4	.723	281	.49
.5	836.0004	5.2	.74	288	.494
.5	820.0004	5	.758	295	.498
.5	804.0004	4.8	.778	303	.5030001
.5	788.0004	4.6	.798	311	.5080001
.5	772.0003	4.4	.823	321	.514
.5	756.0003	4.2	.848	331	.52
.5	740.0003	4	.875	342	.527
.5	724.0003	3.8	.905	354	.534
.5	708.0003	3.6	.94	368	.542
.5	692.0003	3.4	.977	383	.551
.5	676.0003	3.2	1.017	399	.562
.5	660.0003	3	1.065	418	.574
.5	644.0003	2.8	1.12	440	.587
.5	628.0002	2.6	1.18	464	.603
.5	612.0002	2.4	1.252	493	.621
.5	596.0002	2.2	1.337	527	.642

.5	580.0001	2	1.437	567	.668
.5	564.0001	1.8	1.56	616	.699
.5	556.0001	1.7	1.63	644	.717
.5	548.0001	1.6	1.71	676	.738
.5	540.0001	1.5	1.802	713	.762
.5	532.0001	1.4	1.905	754	.789
.5	524.0002	1.3	2.025	802	.82
.5	516.0002	1.2	2.162	857	.856
.5	508.0001	1.1	2.325	922	.899
.5	500.0001	1	2.522	1001	.95
.5	492.0001	.9	2.76	1096	1.013
.5	484.0001	.8	3.06	1216	1.091
.5	476.0001	.7	3.442	1369	1.192
.5	468.0001	.6	3.95	1572	1.326
.5	460.0001	.5	4.663	1857	1.514
.5	452.0001	.4	5.728	2283	1.797
.5	444.0001	.3	7.503	2993	2.267
.5	436	.2	11.048	4411	3.208
.5	428	.1	21.676	8663	6.03
.75	1310.001	10	.525	202	.485
.75	1294.001	9.8	.533	205	.487
.75	1278.001	9.600001	.538	207	.488
.75	1262.001	9.399999	.545	210	.49
.75	1246.001	9.2	.553	213	.491
.75	1230.001	9	.56	216	.493
.75	1214.001	8.8	.565	218	.495
.75	1198.001	8.600001	.575	222	.497
.75	1182.001	8.399999	.583	225	.499
.75	1166.001	8.2	.59	228	.501
.75	1150.001	8	.6	232	.5030001
.75	1134.001	7.8	.608	235	.506
.75	1118.001	7.6	.618	239	.5080001
.75	1102.001	7.4	.628	243	.511
.75	1086.001	7.2	.638	247	.513
.75	1070.001	7	.65	252	.516
.75	1054.001	6.8	.66	256	.519
.75	1038.001	6.6	.673	261	.522
.75	1022	6.4	.685	266	.526
.75	1006	6.2	.7	272	.529
.75	990.0005	6	.715	278	.533
.75	974.0005	5.8	.73	284	.538
.75	958.0005	5.6	.748	291	.542
.75	942.0004	5.4	.765	298	.547
.75	926.0004	5.2	.783	305	.552
.75	910.0004	5	.803	313	.558
.75	894.0004	4.8	.825	322	.564
.75	878.0004	4.6	.85	332	.57
.75	862.0002	4.4	.875	342	.577
.75	846.0003	4.2	.903	353	.585
.75	830.0003	4	.935	366	.594
.75	814.0003	3.8	.967	379	.603
.75	798.0003	3.6	1.005	394	.614
.75	782.0003	3.4	1.047	411	.626
.75	766.0003	3.2	1.095	430	.639
.75	750.0003	3	1.147	451	.654
.75	734.0003	2.8	1.207	475	.671
.75	718.0002	2.6	1.275	502	.691
.75	702.0002	2.4	1.355	534	.714
.75	686.0002	2.2	1.45	572	.742
.75	670.0001	2	1.562	617	.775

.75	654.0001	1.8	1.7	672	.815
.75	646.0001	1.7	1.78	704	.838
.75	638.0001	1.6	1.87	740	.865
.75	630.0001	1.5	1.972	781	.895
.75	622.0001	1.4	2.09	828	.93
.75	614.0001	1.3	2.222	881	.969
.75	606.0001	1.2	2.38	944	1.016
.75	598.0001	1.1	2.565	1018	1.071
.75	590.0001	1	2.785	1106	1.137
.75	582.0001	.9	3.055	1214	1.217
.75	574.0001	.8	3.392	1349	1.317
.75	566.0001	.7	3.823	1521	1.447
.75	558.0001	.6	4.4	1752	1.619
.75	550.0001	.5	5.205	2074	1.86
.75	542	.4	6.41	2556	2.222
.75	534	.3	8.418	3359	2.825
.75	526	.2	12.431	4964	4.032
.75	518	.1	24.465	9779	7.65
1	1400.001	10	.525	202	.495
1	1384.001	9.8	.533	205	.496
1	1368.001	9.600001	.538	207	.498
1	1352.001	9.399999	.545	210	.5
1	1336.001	9.2	.553	213	.502
1	1320.001	9	.56	216	.5030001
1	1304.001	8.8	.568	219	.505
1	1288.001	8.600001	.575	222	.5080001
1	1272.001	8.399999	.583	225	.51
1	1256.001	8.2	.593	229	.5120001
1	1240.001	8	.6	232	.514
1	1224.001	7.8	.61	236	.5170001
1	1208.001	7.6	.62	240	.519
1	1192.001	7.4	.63	244	.522
1	1176.001	7.2	.64	248	.525
1	1160.001	7	.653	253	.528
1	1144.001	6.8	.663	257	.532
1	1128.001	6.6	.675	262	.535
1	1112.001	6.4	.69	268	.539
1	1096	6.2	.703	273	.543
1	1080.001	6	.718	279	.547
1	1064.001	5.8	.735	286	.551
1	1048.001	5.6	.753	293	.556
1	1032	5.4	.77	300	.561
1	1016	5.2	.79	308	.567
1	1000	5	.81	316	.573
1	984.0004	4.8	.833	325	.579
1	968.0004	4.6	.858	335	.587
1	952.0002	4.4	.885	346	.594
1	936.0003	4.2	.913	357	.603
1	920.0002	4	.945	370	.612
1	904.0002	3.8	.98	384	.622
1	888.0002	3.6	1.017	399	.634
1	872.0002	3.4	1.062	417	.646
1	856.0002	3.2	1.11	436	.661
1	840.0002	3	1.165	458	.677
1	824.0003	2.8	1.227	483	.696
1	808.0002	2.6	1.297	511	.717
1	792.0002	2.4	1.38	544	.742
1	776.0002	2.2	1.477	583	.772
1	760.0001	2	1.595	630	.807
	744.0001	1.8	1.737	687	.851

1	736.0001	1.7	1.82	720	.876
1	728.0001	1.6	1.915	758	.905
1	720.0001	1.5	2.02	800	.938
1	712.0001	1.4	2.142	849	.975
1	704.0001	1.3	2.28	904	1.018
1	696.0001	1.2	2.442	969	1.068
1	688.0001	1.1	2.635	1046	1.127
1	680.0001	1	2.862	1137	1.198
1	672.0001	.9	3.142	1249	1.285
1	664.0001	.8	3.492	1389	1.393
1	656.0001	.7	3.943	1569	1.533
1	648.0001	.6	4.54	1808	1.719
1	640.0001	.5	5.375	2142	1.979
1	632	.4	6.628	2643	2.37
1	624	.3	8.715	3478	3.021
1	616	.2	12.883	5145	4.323
1	608	.1	25.387	10148	8.229

CANTILEVER STEEL SHEET PILE EMBEDDED IN COHESIVE SUBSOIL, WITH GRANULAR BACKFILL

OPTION 4
PILE.4 PROGRAM

FILE NO.:	T6.PRN
FIGURE NO.:	6
DESIGNER:	JOSEPH F. STOCK, JR
DATE:	APRIL 8, 1991

BACKFILL ASSUMED FRICTION ANGLE=	30	DEGREES
BACKFILL WET DENSITY=	120	PCF
BACKFILL BUOYANT DENSITY FRACTION=	.6	
HEIGHT OF BACKFILL=	20	FEET

BACKF. ALPHA	SUBSOIL COHESION (PSF)	(2qu-q)/ BBD*Ka*H	DEPTH RATIO D/H	NO. OF TRIALS	MOMENT RATIO
0	1560.001	10	.323	121	.179
0	1536.001	9.8	.325	122	.179
0	1512.001	9.600001	.33	124	.18
0	1488.001	9.399999	.333	125	.18
0	1464.001	9.2	.338	127	.18
0	1440.001	9	.34	128	.181
0	1416.001	8.8	.345	130	.181
0	1392.001	8.600001	.348	131	.181
0	1368.001	8.399999	.353	133	.182
0	1344.001	8.2	.358	135	.182
0	1320.001	8	.36	136	.182
0	1296.001	7.8	.365	138	.183
0	1272.001	7.6	.37	140	.183
0	1248.001	7.4	.375	142	.184
0	1224.001	7.2	.383	145	.184
0	1200.001	7	.388	147	.185
0	1176.001	6.8	.393	149	.185
0	1152.001	6.6	.4	152	.186
0	1128.001	6.4	.405	154	.186
0	1104.001	6.2	.413	157	.187
0	1080.001	6	.42	160	.187
0	1056.001	5.8	.428	163	.188
0	1032.001	5.6	.435	166	.189
0	1008.001	5.4	.445	170	.19
0	984.0006	5.2	.455	174	.191
0	960.0006	5	.465	178	.192
0	936.0005	4.8	.475	182	.193
0	912.0006	4.6	.485	186	.194
0	888.0004	4.4	.498	191	.195
0	864.0005	4.2	.513	197	.196
0	840.0004	4	.525	202	.198
0	816.0005	3.8	.543	209	.2
0	792.0004	3.6	.56	216	.201
0	768.0004	3.4	.58	224	.203
0	744.0004	3.2	.6	232	.206
0	720.0004	3	.625	242	.208
0	696.0003	2.8	.653	253	.211
	672.0003	2.6	.683	265	.215

0	648.0003	2.4	.718	279	.219
0	624.0003	2.2	.76	296	.223
0	600.0003	2	.81	316	.229
0	576.0002	1.8	.87	340	.236
0	564.0002	1.7	.905	354	.24
0	552.0002	1.6	.945	370	.245
0	540.0002	1.5	.99	388	.25
0	528.0001	1.4	1.04	408	.256
0	516.0002	1.3	1.097	431	.263
0	504.0001	1.2	1.165	458	.271
0	492.0001	1.1	1.242	489	.28
0	480.0001	1	1.337	527	.292
0	468.0001	.9	1.452	573	.306
0	456.0001	.8	1.595	630	.323
0	444.0001	.7	1.777	703	.345
0	432.0001	.6	2.02	800	.375
0	420.0001	.5	2.357	935	.417
0	408.0001	.4	2.862	1137	.479
0	396	.3	3.702	1473	.583
0	384	.2	5.375	2142	.792
0	372	.1	10.383	4145	1.417
.25	1620.001	10	.38	144	.252
.25	1596.001	9.8	.385	146	.252
.25	1572.001	9.600001	.39	148	.253
.25	1548.001	9.399999	.393	149	.253
.25	1524.001	9.2	.398	151	.254
.25	1500.001	9	.403	153	.254
.25	1476.001	8.8	.408	155	.255
.25	1452.001	8.600001	.413	157	.255
.25	1428.001	8.399999	.418	159	.256
.25	1404.001	8.2	.423	161	.256
.25	1380.001	8	.428	163	.257
.25	1356.001	7.8	.435	166	.258
.25	1332.001	7.6	.44	168	.258
.25	1308.001	7.4	.445	170	.259
.25	1284.001	7.2	.453	173	.26
.25	1260.001	7	.46	176	.261
.25	1236.001	6.8	.468	179	.262
.25	1212.001	6.6	.475	182	.263
.25	1188.001	6.4	.483	185	.263
.25	1164.001	6.2	.49	188	.265
.25	1140.001	6	.5	192	.266
.25	1116.001	5.8	.51	196	.267
.25	1092.001	5.6	.52	200	.268
.25	1068.001	5.4	.53	204	.27
.25	1044.001	5.2	.543	209	.271
.25	1020.001	5	.555	214	.273
.25	996.0005	4.8	.568	219	.274
.25	972.0006	4.6	.583	225	.276
.25	948.0004	4.4	.598	231	.278
.25	924.0005	4.2	.613	237	.281
.25	900.0004	4	.633	245	.283
.25	876.0004	3.8	.65	252	.286
.25	852.0004	3.6	.673	261	.289
.25	828.0004	3.4	.698	271	.292
.25	804.0004	3.2	.725	282	.296
.25	780.0004	3	.755	294	.3
.25	756.0003	2.8	.788	307	.305
.25	732.0003	2.6	.828	323	.311
.25	708.0003	2.4	.873	341	.318

.25	684.0003	2.2	.925	362	.326
.25	660.0003	2	.99	388	.335
.25	636.0002	1.8	1.065	418	.347
.25	624.0002	1.7	1.11	436	.354
.25	612.0002	1.6	1.16	456	.361
.25	600.0002	1.5	1.217	479	.37
.25	588.0001	1.4	1.282	505	.38
.25	576.0001	1.3	1.355	534	.391
.25	564.0001	1.2	1.44	568	.405
.25	552.0001	1.1	1.542	609	.42
.25	540.0001	1	1.662	657	.439
.25	528.0001	.9	1.81	716	.463
.25	516.0002	.8	1.992	789	.492
.25	504.0001	.7	2.227	883	.529
.25	492.0001	.6	2.54	1008	.578
.25	480.0001	.5	2.975	1182	.648
.25	468.0001	.4	3.625	1442	.752
.25	456.0001	.3	4.708	1875	.926
.25	444.0001	.2	6.865	2738	1.274
.25	432	.1	13.33	5324	2.316
.5	1680.001	10	.41	156	.292
.5	1656.001	9.8	.415	158	.293
.5	1632.001	9.600001	.42	160	.293
.5	1608.001	9.399999	.423	161	.294
.5	1584.001	9.2	.428	163	.294
.5	1560.001	9	.433	165	.295
.5	1536.001	8.8	.44	168	.296
.5	1512.001	8.600001	.445	170	.297
.5	1488.001	8.399999	.45	172	.297
.5	1464.001	8.2	.455	174	.298
.5	1440.001	8	.463	177	.299
.5	1416.001	7.8	.468	179	.3
.5	1392.001	7.6	.475	182	.301
.5	1368.001	7.4	.483	185	.302
.5	1344.001	7.2	.49	188	.303
.5	1320.001	7	.498	191	.304
.5	1296.001	6.8	.505	194	.305
.5	1272.001	6.6	.513	197	.307
.5	1248.001	6.4	.523	201	.308
.5	1224.001	6.2	.533	205	.309
.5	1200.001	6	.543	209	.311
.5	1176.001	5.8	.553	213	.312
.5	1152.001	5.6	.563	217	.314
.5	1128.001	5.4	.575	222	.316
.5	1104.001	5.2	.588	227	.318
.5	1080.001	5	.603	233	.32
.5	1056.001	4.8	.618	239	.322
.5	1032.001	4.6	.633	245	.325
.5	1008	4.4	.65	252	.328
.5	984.0005	4.2	.67	260	.331
.5	960.0004	4	.69	268	.334
.5	936.0004	3.8	.713	277	.338
.5	912.0004	3.6	.738	287	.342
.5	888.0004	3.4	.765	298	.347
.5	864.0004	3.2	.795	310	.352
.5	840.0004	3	.83	324	.358
.5	816.0003	2.8	.868	339	.364
.5	792.0003	2.6	.913	357	.372
.5	768.0003	2.4	.965	378	.381
.5	744.0003	2.2	1.025	402	.392

.5	720.0003	2	1.097	431	.405
.5	696.0002	1.8	1.185	466	.42
.5	684.0002	1.7	1.237	487	.429
.5	672.0002	1.6	1.295	510	.44
.5	660.0002	1.5	1.36	536	.451
.5	648.0001	1.4	1.432	565	.465
.5	636.0001	1.3	1.517	599	.48
.5	624.0001	1.2	1.617	639	.498
.5	612.0001	1.1	1.732	685	.52
.5	600.0001	1	1.872	741	.545
.5	588.0001	.9	2.042	809	.576
.5	576.0001	.8	2.255	894	.615
.5	564.0001	.7	2.525	1002	.666
.5	552.0001	.6	2.887	1147	.733
.5	540.0001	.5	3.39	1348	.826
.5	528.0001	.4	4.145	1650	.967
.5	516	.3	5.4	2152	1.201
.5	504.0001	.2	7.905	3154	1.67
.5	492	.1	15.41	6156	3.076
.75	1740.001	10	.42	160	.309
.75	1716.001	9.8	.425	162	.31
.75	1692.001	9.600001	.43	164	.31
.75	1668.001	9.399999	.435	166	.311
.75	1644.001	9.2	.44	168	.312
.75	1620.001	9	.445	170	.313
.75	1596.001	8.8	.45	172	.314
.75	1572.001	8.600001	.458	175	.314
.75	1548.001	8.399999	.463	177	.315
.75	1524.001	8.2	.468	179	.316
.75	1500.001	8	.475	182	.317
.75	1476.001	7.8	.483	185	.318
.75	1452.001	7.6	.488	187	.319
.75	1428.001	7.4	.495	190	.321
.75	1404.001	7.2	.5030001	193	.322
.75	1380.001	7	.513	197	.323
.75	1356.001	6.8	.52	200	.325
.75	1332.001	6.6	.53	204	.326
.75	1308.001	6.4	.538	207	.328
.75	1284.001	6.2	.548	211	.329
.75	1260.001	6	.56	216	.331
.75	1236.001	5.8	.57	220	.333
.75	1212.001	5.6	.583	225	.335
.75	1188.001	5.4	.595	230	.337
.75	1164.001	5.2	.608	235	.34
.75	1140.001	5	.623	241	.342
.75	1116.001	4.8	.638	247	.345
.75	1092.001	4.6	.655	254	.348
.75	1068.001	4.4	.675	262	.351
.75	1044.001	4.2	.693	269	.355
.75	1020	4	.715	278	.359
.75	996.0004	3.8	.74	288	.363
.75	972.0004	3.6	.765	298	.368
.75	948.0004	3.4	.795	310	.373
.75	924.0004	3.2	.828	323	.379
.75	900.0004	3	.865	338	.386
.75	876.0003	2.8	.908	355	.394
.75	852.0002	2.6	.955	374	.403
.75	828.0003	2.4	1.01	396	.414
.75	804.0003	2.2	1.075	422	.426
.75	780.0003	2	1.152	453	.441

.75	756.0002	1.8	1.247	491	.459
.75	744.0002	1.7	1.302	513	.47
.75	732.0002	1.6	1.365	538	.482
.75	720.0002	1.5	1.435	566	.496
.75	708.0001	1.4	1.512	597	.5120001
.75	696.0001	1.3	1.605	634	.53
.75	684.0001	1.2	1.712	677	.551
.75	672.0001	1.1	1.837	727	.576
.75	660.0001	1	1.987	787	.606
.75	648.0001	.9	2.172	861	.643
.75	636.0001	.8	2.4	952	.689
.75	624.0001	.7	2.695	1070	.748
.75	612.0001	.6	3.085	1226	.826
.75	600.0001	.5	3.63	1444	.936
.75	588.0001	.4	4.445	1770	1.101
.75	576	.3	5.803	2313	1.376
.75	564	.2	8.515001	3398	1.926
.75	552	.1	16.647	6651	3.577
1	1800.001	10	.42	160	.313
1	1776.001	9.8	.425	162	.313
1	1752.001	9.600001	.43	164	.314
1	1728.001	9.399999	.435	166	.315
1	1704.001	9.2	.44	168	.316
1	1680.001	9	.445	170	.316
1	1656.001	8.8	.45	172	.317
1	1632.001	8.600001	.455	174	.318
1	1608.001	8.399999	.463	177	.319
1	1584.001	8.2	.468	179	.32
1	1560.001	8	.475	182	.321
1	1536.001	7.8	.48	184	.322
1	1512.001	7.6	.488	187	.323
1	1488.001	7.4	.495	190	.325
1	1464.001	7.2	.5030001	193	.326
1	1440.001	7	.513	197	.327
1	1416.001	6.8	.52	200	.329
1	1392.001	6.6	.53	204	.33
1	1368.001	6.4	.538	207	.332
1	1344.001	6.2	.55	212	.334
1	1320.001	6	.56	216	.336
1	1296.001	5.8	.57	220	.338
1	1272.001	5.6	.583	225	.34
1	1248.001	5.4	.595	230	.342
1	1224.001	5.2	.61	236	.345
1	1200.001	5	.625	242	.347
1	1176.001	4.8	.64	248	.35
1	1152.001	4.6	.658	255	.353
1	1128.001	4.4	.675	262	.357
1	1104.001	4.2	.698	271	.36
1	1080	4	.718	279	.365
1	1056.001	3.8	.743	289	.369
1	1032	3.6	.77	300	.374
1	1008	3.4	.8	312	.38
1	984.0004	3.2	.833	325	.386
1	960.0004	3	.87	340	.394
1	936.0003	2.8	.913	357	.402
1	912.0002	2.6	.962	377	.411
1	888.0002	2.4	1.017	399	.422
1	864.0002	2.2	1.085	426	.436
1	840.0002	2	1.165	458	.451
1	816.0002	1.8	1.26	496	.471

1	804.0002	1.7	1.317	519	.482
1	792.0002	1.6	1.38	544	.495
1	780.0002	1.5	1.452	573	.509
1	768.0001	1.4	1.535	606	.526
1	756.0001	1.3	1.627	643	.545
1	744.0001	1.2	1.737	687	.567
1	732.0001	1.1	1.867	739	.593
1	720.0001	1	2.02	800	.625
1	708.0001	.9	2.207	875	.664
1	696.0001	.8	2.442	969	.712
1	684.0001	.7	2.742	1089	.774
1	672.0001	.6	3.142	1249	.856
1	660.0001	.5	3.702	1473	.972
1	648.0001	.4	4.54	1808	1.146
1	636	.3	5.933	2365	1.435
1	624	.2	8.715	3478	2.014
1	612	.1	17.052	6813	3.75

APPENDIX E

OPTION 6 GRAPH DATA

ANCHORED SHEET PILE EMBEDDED IN GRANULAR SUBSOIL, WITH GRANULAR BACKFILL

OPTION 6
PILE.4 PROGRAM

FILE NO.:	T7.PRN
FIGURE NO.:	7
DESIGNER:	JOSEPH F. STOCK, JR
DATE:	APRIL 8, 1991
BACKFILL WET DENSITY=	120 PCF
BACKFILL BUOYANT DENSITY FRACTION=	.5
HEIGHT OF BACKFILL=	20 FEET
ANCHOR DEPTH=	5 FEET

ALPHA	FRICTION	Kp/Ka	DEPTH RATIO D/H	NO. OF TRIALS	MOMENT RATIO	ANCHOR RATIO
0	5	1.418	3.928	1092	.94	1.201
0	6	1.521	3.212	806	.719	1.022
0	7	1.632	2.702	602	.573	.894
0	8	1.751	2.32	449	.473	.798
0	9	1.879	2.022	330	.4	.724
0	10	2.017	1.785	235	.345	.665
0	11	2.166	1.59	397	.302	.617
0	12	2.326	1.427	332	.269	.577
0	13	2.498	1.292	278	.24	.541
0	14	2.684	1.175	231	.218	.513
0	15	2.885	1.072	190	.2	.489
0	16	3.101	.985	155	.183	.466
0	17	3.336	.907	124	.169	.446
0	18	3.589	.838	96	.158	.43
0	19	3.863	.778	72	.146	.412
0	20	4.16	.723	50	.137	.398
0	21	4.482	.673	230	.129	.385
0	22	4.831	.625	211	.124	.377
0	23	5.21	.585	195	.116	.365
0	24	5.622	.548	180	.11	.355
0	25	6.071	.513	166	.106	.347
0	26	6.559	.48	153	.102	.34
0	27	7.091	.45	141	.098	.333
0	28	7.672	.425	131	.092	.322
0	29	8.306	.398	120	.091	.32
0	30	9	.375	111	.087	.313
0	31	9.76	.353	102	.084	.308
0	32	10.592	.333	94	.081	.302
0	33	11.506	.313	86	.08	.299
0	34	12.511	.295	79	.077	.294
0	35	13.617	.28	73	.072	.285
0	36	14.837	.263	66	.073	.286
0	37	16.183	.248	60	.071	.282
0	38	17.671	.235	55	.067	.275
	39	19.32	.22	49	6.800001E-02	
0						.277
0	40	21.15	.21	45	.063	.266
0	41	23.184	.197	40	.062	.265
0	42	25.449	.1	1	.045	.227
	43	27.976	.1	1	.026	.177

0	44	30.803	.1	1	8.999999E-03	.121
0	45	33.97	.1	1	-.001	.058
.25	5	1.418	4.833	1454	1.588	1.874
.25	6	1.521	1.2	1	8.999999E-03	.191
.25	7	1.632	3.307	844	.946	1.395
.25	8	1.751	2.832	654	.772	1.246
.25	9	1.879	2.462	506	.648	1.131
.25	10	2.017	2.167	388	.555	1.039
.25	11	2.166	1.927	532	.482	.963
.25	12	2.326	1.727	452	.425	.9
.25	13	2.498	1.56	385	.378	.846
.25	14	2.684	1.415	327	.341	.802
.25	15	2.885	1.292	278	.308	.76
.25	16	3.101	1.182	234	.283	.728
.25	17	3.336	1.087	196	.26	.697
.25	18	3.589	1.002	162	.241	.671
.25	19	3.863	.927	132	.224	.647
.25	20	4.16	.86	105	.209	.625
.25	21	4.482	.8	281	.196	.605
.25	22	4.831	.745	259	.184	.587
.25	23	5.21	.695	239	.174	.571
.25	24	5.622	.65	221	.164	.555
.25	25	6.071	.608	204	.157	.542
.25	26	6.559	.568	188	.151	.533
.25	27	7.091	.533	174	.144	.5210001
.25	28	7.672	.5	161	.138	.51
.25	29	8.306	.47	149	.132	.499
.25	30	9	.443	138	.126	.489
.25	31	9.76	.415	127	.123	.483
.25	32	10.592	.39	117	.119	.477
.25	33	11.506	.368	108	.115	.469
.25	34	12.511	.348	100	.11	.458
.25	35	13.617	.328	92	.106	.451
.25	36	14.837	.308	84	.105	.449
.25	37	16.183	.29	77	.102	.443
.25	38	17.671	.275	71	.096	.432
.25	39	19.32	.258	64	.097	.433
.25	40	21.15	.245	59	.091	.42
.25	41	23.184	.23	53	9.000001E-02	.419
.25	42	25.449	.217	48	.087	.412
.25	43	27.976	.205	43	.085	.408
.25	44	30.803	.1	1	.078	.393
.25	45	33.97	.1	1	.052	.331
.5	5	1.418	5.735	1815	2.457	2.597
.5	6	1.521	1.2	1	-.03	.045
.5	7	1.632	3.908	1084	1.436	1.91
.5	8	1.751	3.34	857	1.161	1.695
.5	9	1.879	2.9	681	.964	1.527
.5	10	2.017	2.547	540	.819	1.396
.5	11	2.166	2.26	665	.708	1.288
.5	12	2.326	2.022	570	.619	1.198
.5	13	2.498	1.822	490	.548	1.121
.5	14	2.684	1.652	422	.489	1.055
.5	15	2.885	1.505	363	.442	.998
.5	16	3.101	1.375	311	.403	.951
.5	17	3.336	1.262	266	.369	.907
	18	3.589	1.162	226	.34	.869

.5	19	3.863	1.075	191	.313	.833
.5	20	4.16	.995	159	.292	.803
.5	21	4.482	.923	330	.274	.777
.5	22	4.831	.858	304	.258	.753
.5	23	5.21	.8	281	.241	.728
.5	24	5.622	.745	259	.23	.71
.5	25	6.071	.698	240	.216	.688
.5	26	6.559	.653	222	.205	.67
.5	27	7.091	.61	205	.197	.657
.5	28	7.672	.573	190	.187	.64
.5	29	8.306	.538	176	.179	.626
.5	30	9	.505	163	.171	.612
.5	31	9.76	.475	151	.164	.599
.5	32	10.592	.445	139	.16	.593
.5	33	11.506	.42	129	.152	.578
.5	34	12.511	.395	119	.148	.569
.5	35	13.617	.373	110	.142	.558
.5	36	14.837	.35	101	.139	.553
.5	37	16.183	.33	93	.134	.543
.5	38	17.671	.31	85	.132	.539
.5	39	19.32	.293	78	.127	.53
.5	40	21.15	.275	71	.125	.526
.5	41	23.184	.26	65	.12	.515
.5	42	25.449	.245	59	.117	.509
.5	43	27.976	.23	53	.116	.506
.5	44	30.803	.217	48	.111	.496
.5	45	33.97	.205	43	.108	.49
.75	5	1.418	6.635	2175	3.563	3.371
.75	6	1.521	1.2	1	-.254	-.23
.75	7	1.632	1.2	1	-.018	.242
.75	8	1.751	3.843	1058	1.638	2.147
.75	9	1.879	3.33	853	1.348	1.921
.75	10	2.017	2.92	689	1.136	1.742
.75	11	2.166	2.587	796	.972	1.595
.75	12	2.326	2.31	685	.846	1.475
.75	13	2.498	2.077	592	.744	1.372
.75	14	2.684	1.88	513	.66	1.283
.75	15	2.885	1.71	445	.591	1.206
.75	16	3.101	1.56	385	.536	1.142
.75	17	3.336	1.43	333	.487	1.083
.75	18	3.589	1.315	287	.446	1.032
.75	19	3.863	1.212	246	.41	.986
.75	20	4.16	1.12	209	.381	.947
.75	21	4.482	1.037	376	.354	.91
.75	22	4.831	.965	347	.329	.874
.75	23	5.21	.898	320	.308	.844
.75	24	5.622	.835	295	.291	.819
.75	25	6.071	.78	273	.273	.791
.75	26	6.559	.728	252	.26	.771
.75	27	7.091	.68	233	.247	.75
.75	28	7.672	.638	216	.234	.729
.75	29	8.306	.598	200	.223	.71
.75	30	9	.56	185	.214	.694
.75	31	9.76	.525	171	.205	.68
.75	32	10.592	.495	159	.194	.66
.75	33	11.506	.465	147	.186	.647
.75	34	12.511	.435	135	.183	.641
.75	35	13.617	.41	125	.175	.626
.75	36	14.837	.385	115	.17	.617
.75	37	16.183	.363	106	.164	.606

.75	38	17.671	.343	98	.156	.59
.75	39	19.32	.323	90	.151	.58
.75	40	21.15	.303	82	.149	.576
.75	41	23.184	.285	75	.144	.567
.75	42	25.449	.268	68	.142	.562
.75	43	27.976	.253	62	.136	.551
.75	44	30.803	.238	56	.133	.544
.75	45	33.97	.222	50	.132	.542
1	5	1.418	7.528	2532	4.72	4.202
1	6	1.521	1.2	1	-.2	-.634
1	7	1.632	1.2	1	-.045	-.014
1	8	1.751	4.34	1257	2.166	2.605
1	9	1.879	3.753	1022	1.78	2.314
1	10	2.017	3.285	835	1.492	2.082
1	11	2.166	2.905	923	1.27	1.892
1	12	2.326	2.59	797	1.097	1.734
1	13	2.498	2.325	691	.957	1.601
1	14	2.684	2.1	601	.843	1.487
1	15	2.885	1.905	523	.751	1.39
1	16	3.101	1.735	455	.675	1.307
1	17	3.336	1.587	396	.608	1.232
1	18	3.589	1.457	344	.551	1.165
1	19	3.863	1.34	297	.506	1.11
1	20	4.16	1.237	256	.463	1.055
1	21	4.482	1.145	419	.426	1.008
1	22	4.831	1.06	385	.396	.968
1	23	5.21	.985	355	.367	.928
1	24	5.622	.915	327	.344	.895
1	25	6.071	.853	302	.321	.862
1	26	6.559	.795	279	.301	.833
1	27	7.091	.743	258	.283	.806
1	28	7.672	.693	238	.27	.785
1	29	8.306	.648	220	.256	.763
1	30	9	.608	204	.241	.739
1	31	9.76	.568	188	.232	.724
1	32	10.592	.533	174	.22	.705
1	33	11.506	.5	161	.21	.687
1	34	12.511	.47	149	.199	.669
1	35	13.617	.44	137	.193	.659
1	36	14.837	.413	126	.187	.648
1	37	16.183	.388	116	.18	.635
1	38	17.671	.365	107	.172	.619
1	39	19.32	.343	98	.167	.61
1	40	21.15	.323	90	.16	.597
1	41	23.184	.303	82	.156	.59
1	42	25.449	.285	75	.149	.577
1	43	27.976	.268	68	.146	.57
1	44	30.803	.253	62	.138	.555
1	45	33.97	.235	55	.141	.56

ANCHORED SHEET PILE EMBEDDED IN GRANULAR SUBSOIL, WITH GRANULAR BACKFILL

OPTION 6
PILE.4 PROGRAM

FILE NO.: T8.PRN
FIGURE NO.: 8
DESIGNER: JOSEPH F. STOCK, JR
DATE: APRIL 8, 1991

BACKFILL WET DENSITY= 120 PCF
BACKFILL BUOYANT DENSITY FRACTION= .4
HEIGHT OF BACKFILL= 20 FEET
ANCHOR DEPTH= 5 FEET

ALPHA	FRICTION	Kp/Ka	DEPTH RATIO D/H	NO. OF TRIALS	MOMENT RATIO	ANCHOR RATIO
0	5	1.418	3.928	1092	.94	1.201
0	6	1.521	3.212	806	.719	1.022
0	7	1.632	2.702	602	.573	.894
0	8	1.751	2.32	449	.473	.798
0	9	1.879	2.022	330	.4	.724
0	10	2.017	1.785	235	.345	.665
0	11	2.166	1.59	397	.302	.617
0	12	2.326	1.427	332	.269	.577
0	13	2.498	1.292	278	.24	.541
0	14	2.684	1.175	231	.218	.513
0	15	2.885	1.072	190	.2	.489
0	16	3.101	.985	155	.183	.466
0	17	3.336	.907	124	.169	.446
0	18	3.589	.838	96	.158	.43
0	19	3.863	.778	72	.146	.412
0	20	4.16	.723	50	.137	.398
0	21	4.482	.673	230	.129	.385
0	22	4.831	.625	211	.124	.377
0	23	5.21	.585	195	.116	.365
0	24	5.622	.548	180	.11	.355
0	25	6.071	.513	166	.106	.347
0	26	6.559	.48	153	.102	.34
0	27	7.091	.45	141	.098	.333
0	28	7.672	.425	131	.092	.322
0	29	8.306	.398	120	.091	.32
0	30	9	.375	111	.087	.313
0	31	9.76	.353	102	.084	.308
0	32	10.592	.333	94	.081	.302
0	33	11.506	.313	86	.08	.299
0	34	12.511	.295	79	.077	.294
0	35	13.617	.28	73	.072	.285
0	36	14.837	.263	66	.073	.286
0	37	16.183	.248	60	.071	.282
0	38	17.671	.235	55	.067	.275
0	39	19.32	.22	49	6.800001E-02	.277
0	40	21.15	.21	45	.063	.266
0	41	23.184	.197	40	.062	.265
0	42	25.449	.1	1	.045	.227
0	43	27.976	.1	1	.026	.177

0	44	30.803	.1	1	8.999999E-03	.121
0	45	33.97	.1	1	-.001	.058
.25	5	1.418	5.285	1635	1.992	2.252
.25	6	1.521	1.2	1	-.002	.157
.25	7	1.632	3.607	964	1.176	1.675
.25	8	1.751	3.087	756	.954	1.493
.25	9	1.879	2.682	594	.796	1.353
.25	10	2.017	2.357	464	.68	1.243
.25	11	2.166	2.095	599	.588	1.151
.25	12	2.326	1.877	512	.515	1.073
.25	13	2.498	1.692	438	.458	1.01
.25	14	2.684	1.535	375	.411	.955
.25	15	2.885	1.397	320	.373	.909
.25	16	3.101	1.28	273	.339	.867
.25	17	3.336	1.175	231	.313	.832
.25	18	3.589	1.082	194	.289	.8
.25	19	3.863	1.002	162	.266	.768
.25	20	4.16	.927	132	.25	.744
.25	21	4.482	.863	306	.233	.719
.25	22	4.831	.803	282	.219	.698
.25	23	5.21	.748	260	.207	.68
.25	24	5.622	.698	240	.196	.663
.25	25	6.071	.653	222	.186	.646
.25	26	6.559	.61	205	.178	.633
.25	27	7.091	.573	190	.169	.617
.25	28	7.672	.538	176	.161	.603
.25	29	8.306	.505	163	.153	.591
.25	30	9	.473	150	.15	.585
.25	31	9.76	.445	139	.143	.573
.25	32	10.592	.42	129	.136	.56
.25	33	11.506	.395	119	.132	.552
.25	34	12.511	.373	110	.127	.542
.25	35	13.617	.35	101	.124	.537
.25	36	14.837	.33	93	.12	.528
.25	37	16.183	.31	85	.118	.525
.25	38	17.671	.293	78	.114	.5170001
.25	39	19.32	.275	71	.112	.514
.25	40	21.15	.26	65	.108	.505
.25	41	23.184	.245	59	.105	.499
.25	42	25.449	.23	53	.105	.498
.25	43	27.976	.217	48	.1	.489
.25	44	30.803	.205	43	.098	.484
.25	45	33.97	.1	1	9.000001E-02	.467
.5	5	1.418	6.635	2175	3.578	3.465
.5	6	1.521	1.2	1	-.086	-.137
.5	7	1.632	4.508	1324	2.052	2.528
.5	8	1.751	3.845	1059	1.649	2.238
.5	9	1.879	3.332	854	1.359	2.012
.5	10	2.017	2.922	690	1.147	1.833
.5	11	2.166	2.59	797	.984	1.685
.5	12	2.326	2.315	687	.854	1.562
.5	13	2.498	2.082	594	.752	1.459
.5	14	2.684	1.885	515	.669	1.37
.5	15	2.885	1.712	446	.602	1.296
.5	16	3.101	1.565	387	.544	1.228
.5	17	3.336	1.435	335	.495	1.169
.5	18	3.589	1.32	289	.454	1.117
.5	19	3.863	1.217	248	.419	1.071

.5	20	4.16	1.125	211	.389	1.032
.5	21	4.482	1.042	378	.363	.995
.5	22	4.831	.967	348	.34	.963
.5	23	5.21	.9	321	.319	.932
.5	24	5.622	.84	297	.299	.902
.5	25	6.071	.785	275	.281	.874
.5	26	6.559	.733	254	.268	.853
.5	27	7.091	.685	235	.255	.832
.5	28	7.672	.643	218	.241	.81
.5	29	8.306	.603	202	.23	.791
.5	30	9	.565	187	.22	.774
.5	31	9.76	.53	173	.212	.76
.5	32	10.592	.498	160	.204	.746
.5	33	11.506	.468	148	.197	.733
.5	34	12.511	.44	137	.189	.718
.5	35	13.617	.415	127	.18	.702
.5	36	14.837	.39	117	.175	.693
.5	37	16.183	.368	108	.169	.68
.5	38	17.671	.345	99	.166	.674
.5	39	19.32	.325	91	.161	.664
.5	40	21.15	.305	83	.158	.659
.5	41	23.184	.288	76	.153	.649
.5	42	25.449	.273	70	.145	.632
.5	43	27.976	.255	63	.145	.632
.5	44	30.803	.24	57	.141	.624
.5	45	33.97	.225	51	.14	.622
.75	5	1.418	7.983	2714	5.778	4.836
.75	6	1.521	1.2	1	-.511	-.673
.75	7	1.632	1.2	1	-.16	.027
.75	8	1.751	4.598	1360	2.569	3.033
.75	9	1.879	3.975	1111	2.098	2.703
.75	10	2.017	3.48	913	1.75	2.439
.75	11	2.166	3.077	992	1.485	2.223
.75	12	2.326	2.742	858	1.282	2.046
.75	13	2.498	2.462	746	1.117	1.894
.75	14	2.684	2.222	650	.986	1.767
.75	15	2.885	2.017	568	.877	1.655
.75	16	3.101	1.837	496	.789	1.56
.75	17	3.336	1.682	434	.71	1.473
.75	18	3.589	1.542	378	.649	1.401
.75	19	3.863	1.42	329	.594	1.334
.75	20	4.16	1.31	285	.547	1.275
.75	21	4.482	1.212	446	.504	1.22
.75	22	4.831	1.125	411	.466	1.169
.75	23	5.21	1.042	378	.438	1.131
.75	24	5.622	.97	349	.409	1.09
.75	25	6.071	.905	323	.382	1.05
.75	26	6.559	.843	298	.362	1.021
.75	27	7.091	.788	276	.341	.988
.75	28	7.672	.738	256	.321	.956
.75	29	8.306	.69	237	.304	.93
.75	30	9	.645	219	.292	.91
.75	31	9.76	.605	203	.278	.886
.75	32	10.592	.568	188	.265	.864
.75	33	11.506	.533	174	.254	.845
.75	34	12.511	.5	161	.243	.827
.75	35	13.617	.47	149	.233	.808
.75	36	14.837	.44	137	.228	.799
.75	37	16.183	.415	127	.216	.778
.75	38	17.671	.39	117	.209	.764

.75	39	19.32	.368	108	.2	.747
.75	40	21.15	.345	99	.195	.737
.75	41	23.184	.325	91	.187	.722
.75	42	25.449	.305	83	.183	.714
.75	43	27.976	.288	76	.176	.699
.75	44	30.803	.27	69	.171	.691
.75	45	33.97	.253	62	.17	.689
1	5	1.418	9.325	3251	8.046	6.372
1	6	1.521	1.2	1	-.415	-1.453
1	7	1.632	1.2	1	-.171	-.479
1	8	1.751	1.2	1	-.023	.115
1	9	1.879	4.613	1366	2.945	3.427
1	10	2.017	4.03	1133	2.449	3.065
1	11	2.166	3.557	1184	2.068	2.768
1	12	2.326	3.165	1027	1.771	2.523
1	13	2.498	2.835	895	1.535	2.318
1	14	2.684	2.555	783	1.343	2.141
1	15	2.885	2.312	686	1.187	1.992
1	16	3.101	2.102	602	1.057	1.862
1	17	3.336	1.92	529	.945	1.745
1	18	3.589	1.757	464	.854	1.646
1	19	3.863	1.615	407	.772	1.554
1	20	4.16	1.485	355	.708	1.478
1	21	4.482	1.372	510	.644	1.402
1	22	4.831	1.267	468	.596	1.341
1	23	5.21	1.175	431	.549	1.281
1	24	5.622	1.09	397	.509	1.229
1	25	6.071	1.012	366	.475	1.182
1	26	6.559	.943	338	.442	1.137
1	27	7.091	.878	312	.415	1.099
1	28	7.672	.82	289	.387	1.057
1	29	8.306	.765	267	.365	1.025
1	30	9	.715	247	.344	.993
1	31	9.76	.668	228	.328	.967
1	32	10.592	.625	211	.311	.939
1	33	11.506	.585	195	.296	.915
1	34	12.511	.548	180	.283	.893
1	35	13.617	.515	167	.265	.864
1	36	14.837	.483	154	.255	.846
1	37	16.183	.453	142	.244	.827
1	38	17.671	.425	131	.233	.807
1	39	19.32	.398	120	.227	.796
1	40	21.15	.373	110	.22	.783
1	41	23.184	.35	101	.21	.766
1	42	25.449	.328	92	.206	.758
1	43	27.976	.308	84	.198	.743
1	44	30.803	.29	77	.187	.722
1	45	33.97	.273	70	.18	.707

ANCHORED SHEET PILE EMBEDDED IN GRANULAR SUBSOIL, WITH GRANULAR BACKFILL

OPTION 6
PILE.4 PROGRAM

FILE NO.: T9.PRN
FIGURE NO.: 9
DESIGNER: JOSEPH F. STOCK, JR
DATE: APRIL 8, 1991

BACKFILL WET DENSITY= 120 PCF
BACKFILL BUOYANT DENSITY FRACTION= .6
HEIGHT OF BACKFILL= 20 FEET
ANCHOR DEPTH= 5 FEET

ALPHA	FRICTION	Kp/Ka	DEPTH RATIO D/H	NO. OF TRIALS	MOMENT RATIO	ANCHOR RATIO
0	5	1.418	3.928	1092	.94	1.201
0	6	1.521	3.212	806	.719	1.022
0	7	1.632	2.702	602	.573	.894
0	8	1.751	2.32	449	.473	.798
0	9	1.879	2.022	330	.4	.724
0	10	2.017	1.785	235	.345	.665
0	11	2.166	1.59	397	.302	.617
0	12	2.326	1.427	332	.269	.577
0	13	2.498	1.292	278	.24	.541
0	14	2.684	1.175	231	.218	.513
0	15	2.885	1.072	190	.2	.489
0	16	3.101	.985	155	.183	.466
0	17	3.336	.907	124	.169	.446
0	18	3.589	.838	96	.158	.43
0	19	3.863	.778	72	.146	.412
0	20	4.16	.723	50	.137	.398
0	21	4.482	.673	230	.129	.385
0	22	4.831	.625	211	.124	.377
0	23	5.21	.585	195	.116	.365
0	24	5.622	.548	180	.11	.355
0	25	6.071	.513	166	.106	.347
0	26	6.559	.48	153	.102	.34
0	27	7.091	.45	141	.098	.333
0	28	7.672	.425	131	.092	.322
0	29	8.306	.398	120	.091	.32
0	30	9	.375	111	.087	.313
0	31	9.76	.353	102	.084	.308
0	32	10.592	.333	94	.081	.302
0	33	11.506	.313	86	.08	.299
0	34	12.511	.295	79	.077	.294
0	35	13.617	.28	73	.072	.285
0	36	14.837	.263	66	.073	.286
0	37	16.183	.248	60	.071	.282
0	38	17.671	.235	55	.067	.275
0	39	19.32	.22	49	6.800001E-02	.277
0	40	21.15	.21	45	.063	.266
0	41	23.184	.197	40	.062	.265
0	42	25.449	.1	1	.045	.227
0	43	27.976	.1	1	.026	.177

0	44	30.803	.1	1	8.999999E-03	.121
0	45	33.97	.1	1	-.001	.058
.25	5	1.418	4.533	1334	1.348	1.636
.25	6	1.521	3.7	1001	1.022	1.393
.25	7	1.632	3.107	764	.809	1.219
.25	8	1.751	2.662	586	.663	1.089
.25	9	1.879	2.317	448	.557	.988
.25	10	2.017	2.042	338	.477	.907
.25	11	2.166	1.817	488	.416	.841
.25	12	2.326	1.63	413	.367	.787
.25	13	2.498	1.472	350	.328	.74
.25	14	2.684	1.337	296	.295	.7
.25	15	2.885	1.22	249	.269	.667
.25	16	3.101	1.117	208	.247	.638
.25	17	3.336	1.027	172	.228	.612
.25	18	3.589	.95	141	.21	.586
.25	19	3.863	.877	112	.197	.567
.25	20	4.16	.815	87	.184	.547
.25	21	4.482	.758	264	.173	.531
.25	22	4.831	.705	243	.164	.516
.25	23	5.21	.658	224	.155	.5030001
.25	24	5.622	.615	207	.147	.489
.25	25	6.071	.575	191	.14	.478
.25	26	6.559	.54	177	.133	.465
.25	27	7.091	.5080001	164	.126	.453
.25	28	7.672	.475	151	.122	.447
.25	29	8.306	.448	140	.116	.436
.25	30	9	.42	129	.113	.43
.25	31	9.76	.395	119	.109	.423
.25	32	10.592	.373	110	.105	.415
.25	33	11.506	.35	101	.102	.411
.25	34	12.511	.33	93	.099	.404
.25	35	13.617	.313	86	9.399999E-02	.394
.25	36	14.837	.293	78	9.399999E-02	.395
.25	37	16.183	.278	72	.089	.385
.25	38	17.671	.263	66	.086	.378
.25	39	19.32	.248	60	.084	.373
.25	40	21.15	.233	54	.083	.372
.25	41	23.184	.22	49	.08	.366
.25	42	25.449	.207	44	.078	.362
.25	43	27.976	.1	1	.076	.358
.25	44	30.803	.1	1	.052	.303
.25	45	33.97	.1	1	.029	.24
.5	5	1.418	5.135	1575	1.85	2.081
.5	6	1.521	1.2	1	-.002	.129
.5	7	1.632	3.507	924	1.096	1.538
.5	8	1.751	3.002	722	.891	1.367
.5	9	1.879	2.61	565	.744	1.235
.5	10	2.017	2.295	439	.636	1.131
.5	11	2.166	2.04	577	.551	1.045
.5	12	2.326	1.827	492	.484	.973
.5	13	2.498	1.647	420	.432	.914
.5	14	2.684	1.495	359	.387	.862
.5	15	2.885	1.362	306	.351	.817
.5	16	3.101	1.247	260	.32	.778
.5	17	3.336	1.147	220	.293	.742
.5	18	3.589	1.057	184	.271	.712

.5	19	3.863	.977	152	.252	.686
.5	20	4.16	.905	123	.236	.663
.5	21	4.482	.84	297	.222	.642
.5	22	4.831	.783	274	.208	.62
.5	23	5.21	.73	253	.196	.601
.5	24	5.622	.683	234	.185	.583
.5	25	6.071	.638	216	.176	.57
.5	26	6.559	.598	200	.167	.554
.5	27	7.091	.56	185	.16	.542
.5	28	7.672	.525	171	.153	.531
.5	29	8.306	.493	158	.148	.5210001
.5	30	9	.463	146	.142	.511
.5	31	9.76	.435	135	.137	.501
.5	32	10.592	.41	125	.131	.49
.5	33	11.506	.385	115	.128	.485
.5	34	12.511	.363	106	.124	.477
.5	35	13.617	.343	98	.118	.467
.5	36	14.837	.323	90	.115	.46
.5	37	16.183	.305	83	.11	.45
.5	38	17.671	.288	76	.107	.444
.5	39	19.32	.27	69	.106	.442
.5	40	21.15	.255	63	.102	.435
.5	41	23.184	.24	57	.101	.431
.5	42	25.449	.228	52	.096	.421
.5	43	27.976	.212	46	.097	.424
.5	44	30.803	.2	41	.096	.421
.5	45	33.97	.1	1	.077	.38
.75	5	1.418	5.735	1815	2.447	2.535
.75	6	1.521	1.2	1	-.125	-.018
.75	7	1.632	3.908	1084	1.426	1.848
.75	8	1.751	3.337	856	1.155	1.635
.75	9	1.879	2.897	680	.957	1.468
.75	10	2.017	2.545	539	.812	1.336
.75	11	2.166	2.257	664	.701	1.229
.75	12	2.326	2.02	569	.613	1.138
.75	13	2.498	1.82	489	.541	1.062
.75	14	2.684	1.647	420	.485	.999
.75	15	2.885	1.5	361	.437	.942
.75	16	3.101	1.372	310	.396	.892
.75	17	3.336	1.26	265	.362	.849
.75	18	3.589	1.16	225	.333	.811
.75	19	3.863	1.07	189	.309	.779
.75	20	4.16	.99	157	.288	.749
.75	21	4.482	.92	329	.267	.719
.75	22	4.831	.855	303	.251	.695
.75	23	5.21	.795	279	.237	.674
.75	24	5.622	.743	258	.223	.652
.75	25	6.071	.693	238	.212	.635
.75	26	6.559	.648	220	.202	.618
.75	27	7.091	.608	204	.191	.6
.75	28	7.672	.57	189	.181	.584
.75	29	8.306	.535	175	.173	.569
.75	30	9	.5030001	162	.165	.556
.75	31	9.76	.47	149	.162	.55
.75	32	10.592	.443	138	.154	.537
.75	33	11.506	.418	128	.147	.523
.75	34	12.511	.393	118	.142	.515
.75	35	13.617	.37	109	.136	.504
.75	36	14.837	.348	100	.133	.498
.75	37	16.183	.328	92	.129	.49

.75	38	17.671	.308	84	.127	.486
.75	39	19.32	.29	77	.123	.477
.75	40	21.15	.273	70	.121	.473
.75	41	23.184	.258	64	.116	.463
.75	42	25.449	.243	58	.113	.457
.75	43	27.976	.228	52	.112	.456
.75	44	30.803	.215	47	.107	.446
.75	45	33.97	.202	42	.104	.44
1	5	1.418	6.33	2053	3.066	3.001
1	6	1.521	1.2	1	-.093	-.235
1	7	1.632	1.2	1	.014	.192
1	8	1.751	3.667	988	1.439	1.893
1	9	1.879	3.18	793	1.187	1.687
1	10	2.017	2.787	636	1.004	1.527
1	11	2.166	2.47	749	.86	1.394
1	12	2.326	2.207	644	.746	1.283
1	13	2.498	1.985	555	.656	1.191
1	14	2.684	1.795	479	.583	1.112
1	15	2.885	1.632	414	.5210001	1.043
1	16	3.101	1.49	357	.471	.984
1	17	3.336	1.365	307	.428	.933
1	18	3.589	1.255	263	.391	.886
1	19	3.863	1.155	223	.362	.849
1	20	4.16	1.067	188	.334	.812
1	21	4.482	.99	357	.308	.777
1	22	4.831	.918	328	.289	.75
1	23	5.21	.855	303	.268	.719
1	24	5.622	.795	279	.253	.698
1	25	6.071	.743	258	.237	.673
1	26	6.559	.693	238	.225	.655
1	27	7.091	.648	220	.213	.636
1	28	7.672	.608	204	.2	.615
1	29	8.306	.568	188	.193	.603
1	30	9	.533	174	.183	.587
1	31	9.76	.5	161	.174	.572
1	32	10.592	.47	149	.166	.557
1	33	11.506	.44	137	.162	.55
1	34	12.511	.415	127	.153	.534
1	35	13.617	.39	117	.147	.524
1	36	14.837	.365	107	.145	.52
1	37	16.183	.345	99	.137	.505
1	38	17.671	.325	91	.132	.495
1	39	19.32	.305	83	.129	.49
1	40	21.15	.288	76	.124	.48
1	41	23.184	.27	69	.121	.475
1	42	25.449	.255	63	.116	.463
1	43	27.976	.24	57	.112	.456
1	44	30.803	.225	51	.111	.454
1	45	33.97	.21	45	.112	.456

APPENDIX F

OPTION 8 GRAPH DATA

ANCHORED SHEET PILE EMBEDDED IN COHESIVE SUBSOIL, WITH GRANULAR BACKFILL

OPTION 8
PILE.4 PROGRAM

FILE NO.: T10.PRN
FIGURE NO.: 10
DESIGNER: JOSEPH F. STOCK, JR
DATE: APRIL 8, 1991

BACKFILL ASSUMED FRICTION ANGLE= 30 DEGREES
BACKFILL WET DENSITY= 120 PCF
BACKFILL BUOYANT DENSITY FRACTION= .5
HEIGHT OF BACKFILL= 20 FEET
ANCHOR DEPTH= 5 FEET

BACKF ALPHA	COHESION (PSF)	(2qu-q)/ BBD*Ka*H	DEPTH RATIO D/H	NO. OF TRIALS	MOMENT RATIO	ANCHOR RATIO
0	1000.001	7	.04	8	.042	.22
0	980.0006	6.8	.04	8	.046	.228
0	960.0007	6.6	.043	9	.042	.219
0	940.0006	6.4	.043	9	.046	.228
0	920.0006	6.2	.045	10	.043	.221
0	900.0006	6	.045	10	.046	.23
0	880.0006	5.8	.048	11	.044	.224
0	860.0006	5.6	.05	12	.042	.22
0	840.0005	5.4	.05	12	.046	.23
0	820.0005	5.2	.053	13	.045	.227
0	800.0005	5	.055	14	.044	.225
0	780.0005	4.8	.058	15	.044	.224
0	760.0005	4.6	.06	16	.044	.224
0	740.0004	4.4	.062	17	.044	.225
0	720.0004	4.2	.065	18	.045	.227
0	700.0004	4	.067	19	.046	.23
0	680.0004	3.8	.07	20	.048	.234
0	660.0004	3.6	.075	22	.046	.23
0	640.0003	3.4	.08	24	.046	.228
0	620.0003	3.2	.082	25	.049	.236
0	600.0003	3	.087	27	.05	.238
0	580.0003	2.8	.095	30	.048	.234
0	560.0003	2.6	.102	33	.048	.234
0	540.0002	2.4	.11	36	.049	.236
0	520.0003	2.2	.117	39	.052	.242
0	500.0002	2	.13	44	.051	.24
0	480.0002	1.8	.142	49	.052	.244
0	460.0001	1.6	.157	55	.054	.248
0	440.0001	1.4	.177	63	.056	.252
0	420.0001	1.2	.205	74	.057	.254
0	400.0001	1	.24	88	.06	.26
0	380.0001	.8	.293	109	.063	.266
0	360.0001	.6	.373	141	6.800001E-02	.276
0	340	.4	.518	199	.076	.293
0	330	.3	.648	251	.083	.306
0	320	.2	.878	343	.093	.324
0	310	.1	1.425	562	.112	.358

.25	1075.001	7	.053	13	.06	.351
.25	1055.001	6.8	.053	13	.064	.362
.25	1035.001	6.6	.055	14	.062	.356
.25	1015.001	6.4	.058	15	.06	.351
.25	995.0006	6.2	.058	15	.064	.362
.25	975.0006	6	.06	16	.063	.359
.25	955.0006	5.8	.062	17	.062	.356
.25	935.0006	5.6	.065	18	.061	.355
.25	915.0005	5.4	.067	19	.061	.354
.25	895.0005	5.2	.07	20	.061	.355
.25	875.0005	5	.072	21	.062	.356
.25	855.0005	4.8	.075	22	.063	.359
.25	835.0005	4.6	.077	23	.064	.362
.25	815.0004	4.4	.08	24	.066	.367
.25	795.0004	4.2	.085	26	.064	.362
.25	775.0004	4	.087	27	.067	.369
.25	755.0004	3.8	.092	29	.066	.367
.25	735.0004	3.6	.097	31	.067	.368
.25	715.0003	3.4	.102	33	6.800001E-02	.37
.25	695.0003	3.2	.107	35	.07	.375
.25	675.0003	3	.115	38	.069	.374
.25	655.0003	2.8	.122	41	.07	.376
.25	635.0003	2.6	.132	45	.069	.374
.25	615.0002	2.4	.142	49	.071	.377
.25	595.0003	2.2	.152	53	.073	.383
.25	575.0002	2	.167	59	.074	.384
.25	555.0002	1.8	.182	65	.077	.39
.25	535.0001	1.6	.205	74	.077	.391
.25	515.0002	1.4	.23	84	7.900001E-02	.397
.25	495.0001	1.2	.263	97	.083	.404
.25	475.0001	1	.308	115	.086	.411
.25	455.0001	.8	.37	140	.092	.423
.25	435.0001	.6	.47	180	.099	.437
.25	415	.4	.645	250	.111	.461
.25	405	.3	.803	313	.12	.478
.25	395	.2	1.075	422	.134	.504
.25	385	.1	1.717	679	.16	.547
.5	1150.001	7	.065	18	.077	.42
.5	1130.001	6.8	.065	18	.083	.433
.5	1110.001	6.6	.067	19	.081	.429
.5	1090.001	6.4	.07	20	.08	.427
.5	1070.001	6.2	.072	21	.08	.426
.5	1050.001	6	.075	22	.08	.425
.5	1030.001	5.8	.077	23	.08	.426
.5	1010.001	5.6	.08	24	.08	.427
.5	990.0005	5.4	.082	25	.081	.43
.5	970.0005	5.2	.085	26	.083	.433
.5	950.0005	5	.087	27	.085	.438
.5	930.0005	4.8	.092	29	.082	.431
.5	910.0005	4.6	.095	30	.085	.438
.5	890.0004	4.4	.1	32	.084	.435
.5	870.0004	4.2	.102	33	.088	.445
.5	850.0004	4	.107	35	.088	.445
.5	830.0004	3.8	.112	37	.089	.448
.5	810.0004	3.6	.12	40	.087	.443
.5	790.0003	3.4	.125	42	9.000001E-02	.45
.5	770.0003	3.2	.132	45	.091	.451

.5	750.0003	3	.14	48	.092	.455
.5	730.0003	2.8	.15	52	.092	.455
.5	710.0003	2.6	.16	56	9.399999E-02	.459
.5	690.0002	2.4	.172	61	.095	.461
.5	670.0003	2.2	.187	67	.096	.463
.5	650.0002	2	.202	73	.099	.47
.5	630.0002	1.8	.222	81	.101	.475
.5	610.0001	1.6	.248	91	.103	.479
.5	590.0001	1.4	.278	103	.106	.486
.5	570.0001	1.2	.318	119	.11	.494
.5	550.0001	1	.37	140	.115	.505
.5	530.0001	.8	.443	169	.123	.5210001
.5	510.0001	.6	.558	215	.133	.54
.5	490.0001	.4	.763	297	.148	.57
.5	480.0001	.3	.94	368	.16	.593
.5	470.0001	.2	1.252	493	.178	.625
.5	460	.1	1.977	783	.209	.677
.75	1225.001	7	.072	21	.091	.461
.75	1205.001	6.8	.075	22	9.000001E-02	.459
.75	1185.001	6.6	.077	23	.089	.457
.75	1165.001	6.4	.08	24	.089	.457
.75	1145.001	6.2	.082	25	.089	.457
.75	1125.001	6	.085	26	9.000001E-02	.459
.75	1105.001	5.8	.087	27	.091	.461
.75	1085.001	5.6	9.000001E-02	28	.093	.465
.75	1065.001	5.4	.092	29	.095	.469
.75	1045.001	5.2	.097	31	.092	.462
.75	1025.001	5	.1	32	.095	.469
.75	1005.001	4.8	.105	34	.093	.465
.75	985.0005	4.6	.107	35	.098	.474
.75	965.0004	4.4	.112	37	.098	.474
.75	945.0004	4.2	.117	39	.098	.475
.75	925.0004	4	.122	41	.1	.479
.75	905.0004	3.8	.13	44	.098	.475
.75	885.0004	3.6	.135	46	.102	.483
.75	865.0003	3.4	.142	49	.103	.484
.75	845.0003	3.2	.15	52	.105	.489
.75	825.0003	3	.16	56	.105	.489
.75	805.0003	2.8	.17	60	.107	.493
.75	785.0003	2.6	.182	65	.108	.494
.75	765.0002	2.4	.195	70	.111	.501
.75	745.0003	2.2	.212	77	.111	.501
.75	725.0002	2	.23	84	.115	.509
.75	705.0002	1.8	.253	93	.118	.514
.75	685.0001	1.6	.28	104	.121	.5210001
.75	665.0001	1.4	.313	117	.126	.531
.75	645.0001	1.2	.358	135	.131	.54
.75	625.0001	1	.415	158	.138	.554
.75	605.0001	.8	.498	191	.146	.571
.75	585.0001	.6	.623	241	.159	.595
.75	565.0001	.4	.845	330	.178	.631
.75	555	.3	1.04	408	.192	.657
.75	545	.2	1.377	543	.213	.693
.75	535	.1	2.162	857	.249	.753
1	1300.001	7	.077	23	.093	.458
1	1280.001	6.8	.08	24	.092	.456

1	1260.001	6.6	.08	24	.099	.472
1	1240.001	6.4	.082	25	.099	.472
1	1220.001	6.2	.085	26	.1	.473
1	1200.001	6	.087	27	.101	.475
1	1180.001	5.8	.092	29	.096	.464
1	1160.001	5.6	.095	30	.098	.468
1	1140.001	5.4	.097	31	.1	.474
1	1120.001	5.2	.102	33	.097	.467
1	1100.001	5	.105	34	.101	.475
1	1080.001	4.8	.11	36	.099	.472
1	1060.001	4.6	.112	37	.104	.483
1	1040	4.4	.117	39	.104	.483
1	1020	4.2	.122	41	.105	.486
1	1000	4	.13	44	.103	.48
1	980.0004	3.8	.135	46	.106	.487
1	960.0004	3.6	.142	49	.106	.487
1	940.0003	3.4	.15	52	.107	.49
1	920.0003	3.2	.157	55	.11	.496
1	900.0002	3	.167	59	.111	.498
1	880.0002	2.8	.177	63	.113	.5030001
1	860.0002	2.6	.19	68	.115	.506
1	840.0002	2.4	.205	74	.116	.5080001
1	820.0003	2.2	.222	81	.117	.511
1	800.0002	2	.24	88	.121	.52
1	780.0002	1.8	.265	98	.123	.523
1	760.0001	1.6	.293	109	.127	.532
1	740.0001	1.4	.328	123	.132	.541
1	720.0001	1.2	.373	141	.137	.553
1	700.0001	1	.433	165	.145	.567
1	680.0001	.8	.518	199	.154	.586
1	660.0001	.6	.648	251	.168	.611
1	640.0001	.4	.878	343	.188	.649
1	630	.3	1.08	424	.203	.676
1	620	.2	1.425	562	.226	.715
1	610	.1	2.235	886	.264	.777

ANCHORED SHEET PILE EMBEDDED IN COHESIVE SUBSOIL, WITH GRANULAR BACKFILL

OPTION 8
PILE.4 PROGRAM

FILE NO.: T11.PRN
FIGURE NO.: 11
DESIGNER: JOSEPH F. STOCK, JR
DATE: APRIL 8, 1991

BACKFILL ASSUMED FRICTION ANGLE= 30 DEGREES
BACKFILL WET DENSITY= 120 PCF
BACKFILL BUOYANT DENSITY FRACTION= .4
HEIGHT OF BACKFILL= 20 FEET
ANCHOR DEPTH= 5 FEET

BACKF ALPHA	COHESION (PSF)	(2qu-q)/ BBD*Ka*H	DEPTH RATIO D/H	NO. OF TRIALS	MOMENT RATIO	ANCHOR RATIO
0	800.0006	7	.04	8	.042	.22
0	784.0006	6.8	.04	8	.046	.228
0	768.0006	6.6	.043	9	.042	.219
0	752.0005	6.4	.043	9	.046	.228
0	736.0004	6.2	.045	10	.043	.221
0	720.0005	6	.045	10	.046	.23
0	704.0005	5.8	.048	11	.044	.224
0	688.0005	5.6	.05	12	.042	.22
0	672.0004	5.4	.05	12	.046	.23
0	656.0004	5.2	.053	13	.045	.227
0	640.0004	5	.055	14	.044	.225
0	624.0004	4.8	.058	15	.044	.224
0	608.0004	4.6	.06	16	.044	.224
0	592.0003	4.4	.062	17	.044	.225
0	576.0003	4.2	.065	18	.045	.227
0	560.0003	4	.067	19	.046	.23
0	544.0003	3.8	.07	20	.048	.234
0	528.0003	3.6	.075	22	.046	.23
0	512.0003	3.4	.08	24	.046	.228
0	496.0003	3.2	.082	25	.049	.236
0	480.0003	3	.087	27	.05	.238
0	464.0002	2.8	.095	30	.048	.234
0	448.0002	2.6	.102	33	.048	.234
0	432.0002	2.4	.11	36	.049	.236
0	416.0002	2.2	.117	39	.052	.242
0	400.0002	2	.13	44	.051	.24
0	384.0001	1.8	.142	49	.052	.244
0	368.0001	1.6	.157	55	.054	.248
0	352.0001	1.4	.177	63	.056	.252
0	336.0001	1.2	.205	74	.057	.254
0	320.0001	1	.24	88	.06	.26
0	304.0001	.8	.293	109	.063	.266
0	288.0001	.6	.373	141	6.800001E-02	.276
0	272	.4	.518	199	.076	.293
0	264	.3	.648	251	.083	.306
0	256	.2	.878	343	.093	.324
0	248	.1	1.425	562	.112	.358

.25	890.0006	7	.058	15	.072	.426
.25	874.0006	6.8	.06	16	.07	.42
.25	858.0006	6.6	.062	17	6.800001E-02	.416
.25	842.0004	6.4	.062	17	.073	.428
.25	826.0004	6.2	.065	18	.072	.425
.25	810.0005	6	.067	19	.071	.423
.25	794.0005	5.8	.07	20	.071	.422
.25	778.0005	5.6	.072	21	.071	.422
.25	762.0004	5.4	.075	22	.071	.423
.25	746.0004	5.2	.077	23	.072	.425
.25	730.0004	5	.08	24	.073	.428
.25	714.0004	4.8	.082	25	.075	.432
.25	698.0004	4.6	.087	27	.072	.426
.25	682.0003	4.4	9.000001E-02	28	.075	.432
.25	666.0003	4.2	.095	30	.073	.429
.25	650.0003	4	.097	31	.077	.438
.25	634.0003	3.8	.102	33	.078	.439
.25	618.0003	3.6	.107	35	7.900001E-02	.441
.25	602.0003	3.4	.115	38	.077	.437
.25	586.0003	3.2	.12	40	.08	.444
.25	570.0003	3	.127	43	.081	.446
.25	554.0003	2.8	.137	47	7.900001E-02	.443
.25	538.0002	2.6	.145	50	.083	.451
.25	522.0002	2.4	.157	55	.083	.45
.25	506.0002	2.2	.17	60	.084	.454
.25	490.0002	2	.185	66	.086	.458
.25	474.0001	1.8	.202	73	.089	.464
.25	458.0001	1.6	.225	82	.091	.468
.25	442.0001	1.4	.255	94	.092	.471
.25	426.0001	1.2	.29	108	.096	.48
.25	410.0001	1	.338	127	.101	.491
.25	394.0001	.8	.408	155	.107	.502
.25	378.0001	.6	.515	198	.115	.519
.25	362	.4	.705	274	.129	.546
.25	354	.3	.873	341	.14	.566
.25	346	.2	1.165	458	.156	.595
.25	338	.1	1.852	733	.184	.643
.5	980.0006	7	.075	22	.102	.538
.5	964.0006	6.8	.077	23	.101	.536
.5	948.0006	6.6	.08	24	.101	.535
.5	932.0004	6.4	.082	25	.101	.535
.5	916.0004	6.2	.085	26	.101	.536
.5	900.0005	6	.087	27	.102	.538
.5	884.0005	5.8	9.000001E-02	28	.103	.541
.5	868.0005	5.6	.092	29	.105	.545
.5	852.0004	5.4	.097	31	.102	.536
.5	836.0004	5.2	.1	32	.104	.543
.5	820.0004	5	.105	34	.102	.538
.5	804.0004	4.8	.107	35	.106	.547
.5	788.0004	4.6	.112	37	.105	.545
.5	772.0003	4.4	.117	39	.106	.546
.5	756.0003	4.2	.122	41	.107	.548
.5	740.0003	4	.127	43	.109	.553
.5	724.0003	3.8	.135	46	.107	.55
.5	708.0003	3.6	.14	48	.111	.559

.5	692.0003	3.4	.147	51	.112	.561
.5	676.0003	3.2	.157	55	.111	.559
.5	660.0003	3	.165	58	.115	.568
.5	644.0003	2.8	.177	63	.114	.566
.5	628.0002	2.6	.19	68	.115	.569
.5	612.0002	2.4	.202	73	.119	.577
.5	596.0002	2.2	.22	80	.12	.579
.5	580.0001	2	.237	87	.124	.588
.5	564.0001	1.8	.26	96	.127	.594
.5	548.0001	1.6	.29	108	.129	.598
.5	532.0001	1.4	.325	122	.133	.607
.5	516.0002	1.2	.368	139	.14	.621
.5	500.0001	1	.428	163	.146	.635
.5	484.0001	.8	.513	197	.155	.652
.5	468.0001	.6	.643	249	.167	.677
.5	452.0001	.4	.87	340	.187	.714
.5	444.0001	.3	1.07	420	.202	.742
.5	436	.2	1.415	558	.223	.78
.5	428	.1	2.217	879	.26	.841
.75	1070.001	7	9.000001E-02	28	.113	.573
.75	1054.001	6.8	.092	29	.113	.574
.75	1038.001	6.6	.095	30	.114	.576
.75	1022	6.4	.097	31	.116	.579
.75	1006	6.2	.1	32	.118	.583
.75	990.0005	6	.102	33	.12	.588
.75	974.0005	5.8	.107	35	.116	.58
.75	958.0005	5.6	.11	36	.12	.587
.75	942.0004	5.4	.112	37	.124	.596
.75	926.0004	5.2	.117	39	.122	.592
.75	910.0004	5	.122	41	.121	.591
.75	894.0004	4.8	.127	43	.122	.591
.75	878.0004	4.6	.132	45	.123	.594
.75	862.0002	4.4	.137	47	.125	.598
.75	846.0003	4.2	.142	49	.128	.605
.75	830.0003	4	.15	52	.128	.603
.75	814.0003	3.8	.157	55	.128	.605
.75	798.0003	3.6	.165	58	.131	.609
.75	782.0003	3.4	.172	61	.134	.617
.75	766.0003	3.2	.182	65	.136	.619
.75	750.0003	3	.195	70	.135	.618
.75	734.0003	2.8	.207	75	.137	.622
.75	718.0002	2.6	.22	80	.142	.631
.75	702.0002	2.4	.237	87	.143	.633
.75	686.0002	2.2	.255	94	.147	.642
.75	670.0001	2	.278	103	.15	.648
.75	654.0001	1.8	.303	113	.155	.659
.75	638.0001	1.6	.335	126	.16	.667
.75	622.0001	1.4	.375	142	.165	.678
.75	606.0001	1.2	.425	162	.173	.693
.75	590.0001	1	.493	189	.181	.711
.75	574.0001	.8	.588	227	.193	.733
.75	558.0001	.6	.733	285	.209	.764
.75	542	.4	.987	387	.233	.808
.75	534	.3	1.207	475	.251	.841
.75	526	.2	1.587	627	.278	.886
.75	518	.1	2.47	980	.321	.956
1	1160.001	7	.095	30	.122	.585
1	1144.001	6.8	.097	31	.123	.587
1	1128.001	6.6	.1	32	.124	.59

1	1112.001	6.4	.102	33	.126	.594
1	1096	6.2	.105	34	.128	.599
1	1080.001	6	.11	36	.124	.59
1	1064.001	5.8	.112	37	.127	.598
1	1048.001	5.6	.117	39	.125	.592
1	1032	5.4	.12	40	.129	.602
1	1016	5.2	.125	42	.129	.6
1	1000	5	.13	44	.129	.6
1	984.0004	4.8	.135	46	.129	.602
1	968.0004	4.6	.14	48	.131	.606
1	952.0002	4.4	.145	50	.134	.612
1	936.0003	4.2	.152	53	.133	.61
1	920.0002	4	.157	55	.138	.62
1	904.0002	3.8	.165	58	.139	.623
1	888.0002	3.6	.175	62	.138	.62
1	872.0002	3.4	.182	65	.142	.63
1	856.0002	3.2	.192	69	.144	.634
1	840.0002	3	.205	74	.144	.635
1	824.0003	2.8	.217	79	.147	.641
1	808.0002	2.6	.232	85	.149	.646
1	792.0002	2.4	.25	92	.152	.65
1	776.0002	2.2	.27	100	.154	.656
1	760.0001	2	.293	109	.159	.665
1	744.0001	1.8	.32	120	.163	.674
1	728.0001	1.6	.353	133	.169	.686
1	712.0001	1.4	.395	150	.174	.697
1	696.0001	1.2	.448	171	.183	.713
1	680.0001	1	.518	199	.193	.732
1	664.0001	.8	.618	239	.205	.756
1	648.0001	.6	.768	299	.223	.789
1	632	.4	1.03	404	.25	.838
1	624	.3	1.26	496	.27	.872
1	616	.2	1.652	653	.299	.92
1	608	.1	2.565	1018	.345	.994

ANCHORED SHEET PILE EMBEDDED IN COHESIVE SUBSOIL, WITH GRANULAR BACKFILL

OPTION 8
PILE.4 PROGRAM

FILE NO.: T12.PRN
FIGURE NO.: 12
DESIGNER: JOSEPH F. STOCK, JR
DATE: APRIL 8, 1991

BACKFILL ASSUMED FRICTION ANGLE= 30 DEGREES
BACKFILL WET DENSITY= 120 PCF
BACKFILL BUOYANT DENSITY FRACTION= .6
HEIGHT OF BACKFILL= 20 FEET
ANCHOR DEPTH= 5 FEET

BACKF ALPHA	COHESION (PSF)	(2qu-q)/ BBD*Ka*H	DEPTH RATIO D/H	NO. OF TRIALS	MOMENT RATIO	ANCHOR RATIO
0	1200.001	7	.04	8	.042	.22
0	1176.001	6.8	.04	8	.046	.228
0	1152.001	6.6	.043	9	.042	.219
0	1128.001	6.4	.043	9	.046	.228
0	1104.001	6.2	.045	10	.043	.221
0	1080.001	6	.045	10	.046	.23
0	1056.001	5.8	.048	11	.044	.224
0	1032.001	5.6	.05	12	.042	.22
0	1008.001	5.4	.05	12	.046	.23
0	984.0006	5.2	.053	13	.045	.227
0	960.0006	5	.055	14	.044	.225
0	936.0005	4.8	.058	15	.044	.224
0	912.0006	4.6	.06	16	.044	.224
0	888.0004	4.4	.062	17	.044	.225
0	864.0005	4.2	.065	18	.045	.227
0	840.0004	4	.067	19	.046	.23
0	816.0005	3.8	.07	20	.048	.234
0	792.0004	3.6	.075	22	.046	.23
0	768.0004	3.4	.08	24	.046	.228
0	744.0004	3.2	.082	25	.049	.236
0	720.0004	3	.087	27	.05	.238
0	696.0003	2.8	.095	30	.048	.234
0	672.0003	2.6	.102	33	.048	.234
0	648.0003	2.4	.11	36	.049	.236
0	624.0003	2.2	.117	39	.052	.242
0	600.0003	2	.13	44	.051	.24
0	576.0002	1.8	.142	49	.052	.244
0	552.0002	1.6	.157	55	.054	.248
0	528.0001	1.4	.177	63	.056	.252
0	504.0001	1.2	.205	74	.057	.254
0	480.0001	1	.24	88	.06	.26
0	456.0001	.8	.293	109	.063	.266
0	432.0001	.6	.373	141	6.800001E-02	.276
0	408.0001	.4	.518	199	.076	.293
0	396	.3	.648	251	.083	.306
0	384	.2	.878	343	.093	.324
0	372	.1	1.425	562	.112	.358

.25	1260.001	7	.048	11	.056	.313
.25	1236.001	6.8	.05	12	.053	.306
.25	1212.001	6.6	.05	12	.057	.316
.25	1188.001	6.4	.053	13	.055	.31
.25	1164.001	6.2	.055	14	.053	.305
.25	1140.001	6	.055	14	.057	.316
.25	1116.001	5.8	.058	15	.056	.312
.25	1092.001	5.6	.06	16	.055	.31
.25	1068.001	5.4	.062	17	.054	.308
.25	1044.001	5.2	.062	17	.059	.321
.25	1020.001	5	.065	18	.059	.321
.25	996.0005	4.8	.067	19	.06	.322
.25	972.0006	4.6	.072	21	.056	.312
.25	948.0004	4.4	.075	22	.057	.316
.25	924.0005	4.2	.077	23	.059	.32
.25	900.0004	4	.082	25	.057	.316
.25	876.0004	3.8	.085	26	.06	.323
.25	852.0004	3.6	9.000001E-02	28	.06	.322
.25	828.0004	3.4	.095	30	.06	.323
.25	804.0004	3.2	.1	32	.062	.326
.25	780.0004	3	.107	35	.061	.323
.25	756.0003	2.8	.112	37	.064	.331
.25	732.0003	2.6	.122	41	.062	.327
.25	708.0003	2.4	.13	44	.065	.334
.25	684.0003	2.2	.142	49	.064	.332
.25	660.0003	2	.155	54	.066	.336
.25	636.0002	1.8	.17	60	6.800001E-02	.34
.25	612.0002	1.6	.19	68	.069	.342
.25	588.0001	1.4	.212	77	.072	.348
.25	564.0001	1.2	.243	89	.075	.355
.25	540.0001	1	.285	106	.077	.361
.25	516.0002	.8	.345	130	.082	.37
.25	492.0001	.6	.438	167	.088	.383
.25	468.0001	.4	.605	234	.099	.404
.25	456.0001	.3	.753	293	.107	.42
.25	444.0001	.2	1.01	396	.12	.444
.25	432	.1	1.625	642	.143	.483
.5	1320.001	7	.055	14	.071	.365
.5	1296.001	6.8	.058	15	6.800001E-02	.359
.5	1272.001	6.6	.06	16	.066	.354
.5	1248.001	6.4	.06	16	.071	.366
.5	1224.001	6.2	.062	17	.07	.362
.5	1200.001	6	.065	18	.069	.36
.5	1176.001	5.8	.067	19	6.800001E-02	.358
.5	1152.001	5.6	.07	20	6.800001E-02	.358
.5	1128.001	5.4	.072	21	6.800001E-02	.359
.5	1104.001	5.2	.075	22	.069	.36
.5	1080.001	5	.077	23	.07	.363
.5	1056.001	4.8	.08	24	.071	.366
.5	1032.001	4.6	.082	25	.073	.371
.5	1008	4.4	.087	27	.071	.365
.5	984.0005	4.2	9.000001E-02	28	.074	.372
.5	960.0004	4	.095	30	.073	.37

.5	936.0004	3.8	.1	32	.073	.37
.5	912.0004	3.6	.105	34	.074	.372
.5	888.0004	3.4	.11	36	.075	.376
.5	864.0004	3.2	.117	39	.074	.374
.5	840.0004	3	.125	42	.075	.375
.5	816.0003	2.8	.132	45	.077	.379
.5	792.0003	2.6	.142	49	.077	.38
.5	768.0003	2.4	.152	53	7.900001E-02	.384
.5	744.0003	2.2	.165	58	.08	.387
.5	720.0003	2	.18	64	.081	.39
.5	696.0002	1.8	.197	71	.083	.395
.5	672.0002	1.6	.217	79	.087	.402
.5	648.0001	1.4	.245	90	.089	.407
.5	624.0001	1.2	.28	104	.092	.414
.5	600.0001	1	.328	123	.096	.422
.5	576.0001	.8	.395	150	.102	.434
.5	552.0001	.6	.5	192	.11	.45
.5	528.0001	.4	.685	266	.123	.476
.5	516	.3	.85	332	.133	.495
.5	504.0001	.2	1.135	446	.149	.523
.5	492	.1	1.807	715	.176	.569
.75	1380.001	7	.062	17	.071	.375
.75	1356.001	6.8	.065	18	.069	.371
.75	1332.001	6.6	.065	18	.076	.384
.75	1308.001	6.4	.067	19	.074	.381
.75	1284.001	6.2	.07	20	.073	.379
.75	1260.001	6	.072	21	.073	.378
.75	1236.001	5.8	.075	22	.073	.378
.75	1212.001	5.6	.077	23	.073	.379
.75	1188.001	5.4	.08	24	.074	.381
.75	1164.001	5.2	.082	25	.076	.384
.75	1140.001	5	.085	26	.078	.388
.75	1116.001	4.8	.087	27	.08	.393
.75	1092.001	4.6	.092	29	.077	.387
.75	1068.001	4.4	.095	30	.081	.395
.75	1044.001	4.2	.1	32	.08	.393
.75	1020	4	.105	34	.08	.393
.75	996.0004	3.8	.11	36	.081	.395
.75	972.0004	3.6	.115	38	.083	.399
.75	948.0004	3.4	.122	41	.082	.396
.75	924.0004	3.2	.13	44	.082	.397
.75	900.0004	3	.137	47	.084	.4
.75	876.0003	2.8	.145	50	.087	.407
.75	852.0002	2.6	.155	54	.089	.41
.75	828.0003	2.4	.167	59	.089	.411
.75	804.0003	2.2	.182	65	.089	.411
.75	780.0003	2	.197	71	.093	.418
.75	756.0002	1.8	.217	79	9.399999E-02	.421
.75	732.0002	1.6	.24	88	.098	.428
.75	708.0001	1.4	.27	100	.101	.434
.75	684.0001	1.2	.308	115	.106	.443
.75	660.0001	1	.36	136	.11	.452
.75	636.0001	.8	.433	165	.117	.466
.75	612.0001	.6	.545	210	.127	.485
.75	588.0001	.4	.745	290	.142	.514
.75	576	.3	.92	360	.154	.537
.75	564	.2	1.225	482	.172	.568
.75	552	.1	1.94	768	.202	.619

APPENDIX G

5 1/4" FLOPPY DISK

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