STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION TITLE PAGE

*SEE INSTRUCTIONS ON REVERSE SIDE

▲ 5010.64 (FRONT)

CLIENT & PROJECT	PAGE 1 OF 29 +
PRIVATE FUEL STORAGE, LLC - PRIVATE FUEL STORAGE FACILITY	APPENDICES A-D (92 pp)

CALCULATION TITLE (Indicative of the Objective):	QA CATEGORY (✓)
ALLOWABLE BEARING CAPACITY AND STATIC SETTLEMENT OF STRIP AND SQUARE FOOTINGS	☑ I - NUCLEAR SAFETY RELATED ☐ II ☐ III ☐ ____ OTHER

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CURRENT CALC. NO.	OPTIONAL TASK CODE	OPTIONAL WORK PACKAGE NO.
05996.01	G(B)	07		119

* APPROVALS – SIGNATURE & DATE						
PREPARER(S)/DATE(S)	REVIEWER(S)/DATE(S)	INDEPENDENT REVIEWER(S)/DATE(S)	REV. NO. OR NEW CALC NO.	SUPERSEDES * CALC. NO. OR REV. NO.	CONFIRMATION * REQUIRED (✓) YES	NO
JOHN J. CARTER [signature] MARCH 14, 1997 PAUL J. TRUDEAU 3/17/97 [signature]	PAUL J. TRUDEAU 3/17/97 [signature] ALAN F. BROWN [signature] 3/17/97 JOHN J. CARTER [signature] 3/17/97	Alan F. Brown 3/18/97 [signature]	0		✓	
PAUL J. TRUDEAU 5/16/97 [signature]	Alan F Brown [signature] 5/19/97	Alan F Brown [signature] 5/19/97	1	0		✓

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TABLE OF CONTENTS

REASONS FOR REV 1:

Incorporate changes made in the course of finalizing Calculation 05996.01-G(B)-05, Rev 0:

- $\phi = 30°$
- Bearing capacity FS for design earthquake = 1.1.
- Use G/G_{max} vs shear strain curve recommended by Geomatrix in Calculation 05996.01-G(PO5)-1, Rev 0, for estimating E values.

Add additional calculations to define the allowable bearing capacity as a function of allowable settlement for strip and square footings for various footing widths and depths.

Remove "Confirmation Required", since the bases for the "Requires Confirmation" on pp 1 & 186 of the original issue of this calculation were that some of the input data for this calculation were based on the original issues of Calcs 05996-G(B)-01, -03, and -04, which required confirmation, as well as Calculation 05996.01-G(B)-05, Rev 0, which was not complete at the time that the original issue of this calculation was being prepared. Since that time, those calculations have been finalized and no longer require confirmation; therefore, this calculation no longer requires confirmation as well.

OBJECTIVE:

Determine the gross allowable bearing pressures against a shear failure for strip and square footings for a range of footing widths, depths, and load inclinations. Also determine the gross allowable bearing pressures that will limit the settlement to the allowable settlements recommended in Calculation 05996.01-G(B)-05, Rev 0 (2" for strip footings and 1.5" for square footings).

ASSUMPTIONS/DATA

Figure 1 presents the generalized soil profile. The critical portion of the soil profile from a bearing capacity perspective is the top layer, 0 ft to 30 ft. The groundwater table is greater than 120 ft below grade (Geosphere (1997).

Bearing capacity failure mode for the top layer is a general shear failure.

Footings are spaced far enough apart that adjacent footings will not affect the bearing capacity or total settlement.

FS = 3 is required for static loadings and 1.1 is required for dynamic loadings from the design basis earthquake, as indicated in Calculation 05996.01-G(B)-05 Rev 0.

The soil properties for the top layer are presented in SWEC Calculations 05996.01-G(B)-01, Rev 1, -04, Rev 1, and -05, Rev 0, and are summarized as follows:

Effective-stress strength parameters for drained analyses are estimated to be ϕ = 30° and c = 0, based on the plasticity index of this material.

Total-stress strength parameters for undrained analyses (e.g., dynamic loadings) are estimated to be ϕ = 0° and c = 2.2 ksf, based on unconsolidated-undrained triaxial tests.

Consolidation parameters:

6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calculation 05996.01-G(B)-01, Rev 1

0.294 = CR, See p 4 Calculation 05996.01-G(B)-05, Rev 0

0.014 = RR, See p 4 Calculation 05996.01-G(B)-05, Rev 0

C_α = rate of secondary compression & is $f(\sigma_v/\sigma_{mpp})$, as shown in Figure 2.

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

5010.65

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 5
05996.01	G(B)	07-1		

METHOD:

Bearing Capacity Calculation Methodology

This calculation uses the same method of calculating allowable bearing capacities of footings as is used in Calculation 05996-G(B)-04, Rev 1 (pp 9 & 10). The ultimate bearing capacity was calculated based on Meyerhof's equation:

$$q_{ult} = c\, N_c\, s_c\, d_c\, i_c + \gamma\, D_f\, N_q\, s_q\, d_q\, i_q + 1/2\, \gamma\, B\, N_\gamma\, s_\gamma\, d_\gamma\, i_\gamma$$

where:

$N_c = (N_q - 1)\ \cot(\phi)$ — Eq 2-8 Bowles (1968)

$N_q = e^{\pi \tan\phi}\ \tan^2(45 + \phi/2)$ — Eq 10.32 Das (1990)

$N_\gamma = (N_q - 1)\ \tan(1.4\,\phi)$ — Eq 10.39 Das (1990)

$s_c = 1 + (B/L)(N_q/N_c)$ — Table 10.2 Das (1990)

$s_q = 1 + (B/L)\tan\phi$

$s_\gamma = 1 - 0.4\,(B/L)$

For $D_f/B \leq 1$: $d_c = d_q - (1-d_q) / (N_q \tan\phi)$

$d_q = 1 + 2\tan\phi\ (1 - \sin\phi)^2\, D_f/B$

$d_\gamma = 1$

For $D_f/B > 1$: $d_c = d_q - (1-d_q) / (N_q \tan\phi)$

$d_q = 1+2\tan\phi\ (1 - \sin\phi)^2\ \tan^{-1}(D_f/B)$

$d_\gamma = 1$

For $\phi = 0$: $d_c = 1 + 0.4\tan^{-1}(D_f/B)$

$d_\gamma = 1 + 0.4\,(D_f/B)$

$i_c = (1 - \beta/90)^2$

$i_q = i_c$

$i_\gamma = (1 - \beta/\phi)^2$

The allowable bearing pressure is calculated as:

$$q_{all} = q_{ult} / FS$$

where FS = 3 for static loadings and 1.1 for dynamic loadings from the design basis earthquake.

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

▲5010.65

CALCULATION IDENTIFICATION NUMBER				PAGE 6
J.O. OR W.O. NO. 05996.01	DIVISION & GROUP G(B)	CALCULATION NO. 07 - 1	OPTIONAL TASK CODE	

Settlement Calculation Methodology

This calculation uses the same method of calculating settlements as was used in Calculation 05996-G(B)-03, Rev 1 (pp 5 to 7). Stress distribution with depth was found using the Boussinesq equation (Figure 3.40 of Das 1995, copy included as Figure 3).

Elastic settlement was found using the elastic modulus (E) for the given strain level and the change in vertical effective stress for each sublayer. A value of vertical strain was assumed for each sublayer. Using the G/G_{max} vs shear strain curve recommended by Geomatrix in Calculation 05996.01-G(PO5)-1, Rev 0 (p12/29 of Section 1.3, shown in Figure 4), a corresponding value of G/G_{max} was found. Because E is directly proportional to G, E/E_{max} was assumed to vary with respect to vertical strain as G varies with respect to shear strain. E for the assumed strain level was calculated as $E/E_{max} \bullet E_{max}$. Vertical strain was then calculated as $\Delta\sigma_v / E$, and was compared to the assumed strain. Iterations were performed until the actual strain was approximately equal to the assumed strain.

Primary consolidation settlement was calculated as:

$$\Delta\rho_{primary} = [\Delta H \times 12\ in./ft] \times [RR \times Log(\sigma_{mpp} / \sigma_{vo}) + CR \times Log(\sigma_{vf} / \sigma_{mpp})]$$

where:

6.00 ksf = σ_{mpp}, Maximum past pressure from consolidation tests -

See p 7 Calculation 05996.01-G(B)-01, Rev 1

0.294 = CR, See p 4 Calculation 05996.01-G(B)-05, Rev 0

0.014 = RR, See p 4 Calculation 05996.01-G(B)-05, Rev 0

Secondary compression was calculated as:

$$\Delta\rho_{secondary} = 12\ in./ft \times C_\alpha \times Log_{10}(\Delta t\ in\ min)$$

where:

C_α = rate of secondary compression & is $f(\sigma_{vf}/\sigma_{mpp})$, as shown in Figure 2.

Δt = elapsed time in minutes since end of loading.

DISCUSSION:

Bearing capacity analyses were performed for a variety of footing widths and depths for both strip footings and square footings, for vertical loads, and for loads inclined 10 and 20 degrees from the vertical. These analyses were performed using effective-stress strength parameters to investigate long-term conditions, which are applicable for static loads. For these analyses, the allowable bearing pressure was determined using a factor of safety of 3. Bearing capacity analyses also were performed using total-stress strength parameters, which are applicable for earthquake loads. For these analyses, the allowable bearing pressure was determined using a factor of safety of 1.1.

Appendix A presents detailed calculations of the allowable bearing capacity for static loadings for 4 ft wide strip and square footings placed at a depth of 4 ft, for vertical loads, and for loads inclined 10 and 20 degrees from the vertical. These calculations follow the method described above using the effective-stress strength parameters, and the required factor of safety is 3.

Appendix B presents similar calculations determining the allowable bearing capacity to resist dynamic loads due to the design earthquake. These calculations follow the method described above using the total-stress strength parameters, and the required factor of safety is 1.1.

These calculations were repeated for other combinations of footing widths and depths, and the results are summarized in Tables 1 through 4. These tables are all organized in the same manner; i.e., Sheet A (Table 1A, 2A, 3A, and 4A) summarizes the allowable bearing capacity for footings subjected to vertical loads. Sheets B and C summarize the allowable bearing capacity for footings subjected to loads inclined 10 and 20 degrees from the vertical, respectively.

Table 1 presents the allowable bearing capacities for strip footings subjected to static loads, and Table 2 presents the allowable bearing capacities for square footings. Tables 3 and 4 are organized in the same manner, but they provide summaries of the allowable bearing capacities for strip and square footings, respectively, to resist dynamic loads due to the design earthquake. For these analyses, total-stress strength parameters were used, and the required factor of safety was 1.1

Review of these tables indicates that the static analyses yield the minimum allowable bearing pressures, primarily due to the higher factor of safety required for static conditions. These results are plotted in Figures 5 and 6 as the horizontal lines originating from the vertical axis. These allowable bearing capacities are applicable for vertical loads applied at the center of the footings. For inclined or eccentrically applied loads, they must be reduced. For loadings inclined at 10 degrees from the vertical, they must be reduced by ~25%, and for loadings inclined at 20 degrees from the vertical, they must be reduced by ~50%. Eccentric loads are addressed using the concept of "effective footing width,"

where the effective width (and length, if appropriate) of the footing is determined as shown at the bottom of these figures.

Analyses were performed to estimate the expected settlement of various strip and square footings due to various loadings. These analyses are included in Appendices C & D. Appendix C presents the calculation of allowable bearing pressures to limit the settlement to 2" for strip footings and Appendix D presents those for limiting the settlement of square footings to 1.5". These results are summarized in Tables 5 & 6, respectively. They are also presented in Figures 5 and 6, superimposed on plots of the results of the allowable bearing pressure to obtain a factor of safety against a shear failure of 3.0 for static loads.

In these figures, the horizontal lines represent the allowable bearing pressure that will provide the required factor of safety against a shear failure, and the curves represent the bearing pressure that will result in a given amount of settlement. As indicated, the bearing pressure based on shear failure increases with increasing depth (and, typically, increasing width) of footing. Footing settlement increases as the load increases; therefore, for a given bearing pressure, as the width of the footing increases, there comes a point at which the amount of settlement exceeds the allowable settlement. Thus, as the footing width increases beyond this point, the allowable bearing pressure must decrease, as shown by the curves in Figure 6, in order to limit the settlement to a tolerable value.

CONCLUSIONS:

The proposed structures will be founded on strip and spread footings. The allowable bearing capacity of these footings is limited by shear failure of the soil underlying the footing and by footing settlement. Figures 5 and 6 summarize the results of this calculation and present the gross allowable bearing pressures for strip and square footings.

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

▲ 5010.65

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE
05996.01	G(B)	07 - 1		9

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- Das, B., 1995, Principles of Foundation Engineering, PWS-Kent, Boston MA
- Geomatrix (1997), PFSF Calculation 05996.01-G(P05)-1, Rev 0, "Development of Soil and Foundation Parameters in Support of Dynamic Soil-structure Interaction Analyses," prepared by Geomatrix Consultants, Inc, San Francisco, CA, March 1997.
- Geosphere Midwest, PFSF Report No. 0599601-G(PO9)-1, Rev 0, "Seismic Survey of the Private Fuel Storage Facility—Skull Valley, Utah," prepared for Stone & Webster Engineering Corp by Geosphere Midwest, Midland, MI, February 1997.
- SWEC Calculation "Document Bases for Recommended Values of Dynamic Soil Properties and Coefficient of Subgrade Reaction," 05996.01-G(B)-01, Rev 1, Boston, MA
- SWEC Calculation "Estimate Static Settlement of Storage Pads," 05996.01-G(B)-03, Rev 1, Boston, MA
- SWEC Calculation "Stability Analyses of Storage Pads," 05996.01-G(B)-04, Rev 1, Boston, MA
- SWEC Calculation "Document Bases for Geotechnical Parameters Provided in Geotechnical Design Criteria," 05996.01-G(B)-05, Rev 0, Boston, MA

TABLE 1A - STATIC

SUMMARY - ALLOWABLE BEARING CAPACITY STRIP FOOTINGS $q_{all} = q_{ult} / FS$

ϕ = 30 Effective Stress Friction Angle (degrees)
c = 0 Cohesion (psf)
γ = 80 Unit weight of soil (pcf)
γ_{surch} = 80 Unit weight of surcharge (pcf)
β = 0 Angle of load inclination from vertical (degrees)
FS = 3 Factor of Safety

Assume strip footing if L/B > 5
B = 4 Footing Width (ft)
L = 100 Footing Length (ft)
D_f = 4 Depth of Footing (ft)

D_f ft	B ft	q_{all} psf	q_{ult} = psf	$\gamma_{surch} \cdot D_f$ psf	$\cdot N_q$	$\cdot s_q$	$\cdot d_q$	$\cdot i_q$	$+ \frac{1}{2} \gamma B$	$\cdot N_\gamma$	$\cdot s_\gamma$	$\cdot d_\gamma$	$\cdot i_\gamma$
2.5	1	1,850	5,571	200	18.40	1.00	1.34	1.00	40	15.67	1.00	1.00	1.00
2.5	2	1,960	5,886	200	18.40	1.00	1.26	1.00	80	15.67	1.00	1.00	1.00
2.5	3	2,140	6,446	200	18.40	1.00	1.24	1.00	120	15.67	1.00	1.00	1.00
2.5	4	2,280	6,851	200	18.40	1.00	1.18	1.00	160	15.67	1.00	1.00	1.00
2.5	6	2,620	7,883	200	18.40	1.00	1.12	1.00	240	15.67	1.00	1.00	1.00
2.5	8	3,000	9,026	200	18.40	1.00	1.09	1.00	320	15.67	1.00	1.00	1.00
4	1	2,920	8,769	320	18.40	1.00	1.38	1.00	40	15.67	1.00	1.00	1.00
4	2	3,000	9,024	320	18.40	1.00	1.32	1.00	80	15.67	1.00	1.00	1.00
4	3	3,110	9,345	320	18.40	1.00	1.27	1.00	120	15.67	1.00	1.00	1.00
4	4	3,360	10,095	320	18.40	1.00	1.29	1.00	160	15.67	1.00	1.00	1.00
4	6	3,590	10,782	320	18.40	1.00	1.19	1.00	240	15.67	1.00	1.00	1.00
6	1	4,340	13,043	480	18.40	1.00	1.41	1.00	40	15.67	1.00	1.00	1.00
6	2	4,420	13,271	480	18.40	1.00	1.36	1.00	80	15.67	1.00	1.00	1.00
6	3	4,510	13,536	480	18.40	1.00	1.32	1.00	120	15.67	1.00	1.00	1.00
6	4	4,610	13,845	480	18.40	1.00	1.28	1.00	160	15.67	1.00	1.00	1.00
8	1	5,770	17,321	640	18.40	1.00	1.42	1.00	40	15.67	1.00	1.00	1.00
8	2	5,840	17,537	640	18.40	1.00	1.38	1.00	80	15.67	1.00	1.00	1.00
8	3	5,920	17,777	640	18.40	1.00	1.35	1.00	120	15.67	1.00	1.00	1.00
8	4	6,010	18,048	640	18.40	1.00	1.32	1.00	160	15.67	1.00	1.00	1.00

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TABLE 1B - STATIC

SUMMARY - ALLOWABLE BEARING CAPACITY STRIP FOOTINGS $q_{all} = q_{ult} / FS$

ϕ = 30 Effective Stress Friction Angle (degrees)
c = 0 Cohesion (psf)
γ = 80 Unit weight of soil (pcf)
γ_{surch} = 80 Unit weight of surcharge (pcf)
β = 10 Angle of load inclination from vertical (degrees)
FS = 3 Factor of Safety

Assume strip footing if L/B > 5
B = 4 Footing Width (ft)
L = 100 Footing Length (ft)
D_f = 4 Depth of Footing (ft)

D_f ft	B ft	q_{all} psf	q_{ult} = psf	$\gamma_{surch} \cdot D_f$ psf	$\cdot N_q$	$\cdot s_q$	$\cdot d_q$	$\cdot i_q$	$+ ½ \gamma B$	$\cdot N_\gamma$	$\cdot s_\gamma$	$\cdot d_\gamma$	$\cdot i_\gamma$
2.5	1	1,390	4,186	200	18.40	1.00	1.34	0.79	40	15.67	1.00	1.00	0.44
2.5	2	1,400	4,217	200	18.40	1.00	1.26	0.79	80	15.67	1.00	1.00	0.44
2.5	3	1,480	4,443	200	18.40	1.00	1.24	0.79	120	15.67	1.00	1.00	0.44
2.5	4	1,510	4,547	200	18.40	1.00	1.18	0.79	160	15.67	1.00	1.00	0.44
2.5	6	1,640	4,929	200	18.40	1.00	1.12	0.79	240	15.67	1.00	1.00	0.44
2.5	8	1,790	5,398	200	18.40	1.00	1.09	0.79	320	15.67	1.00	1.00	0.44
4	1	2,230	6,712	320	18.40	1.00	1.38	0.79	40	15.67	1.00	1.00	0.44
4	2	2,230	6,697	320	18.40	1.00	1.32	0.79	80	15.67	1.00	1.00	0.44
4	3	2,240	6,734	320	18.40	1.00	1.27	0.79	120	15.67	1.00	1.00	0.44
4	4	2,360	7,110	320	18.40	1.00	1.29	0.79	160	15.67	1.00	1.00	0.44
4	6	2,400	7,219	320	18.40	1.00	1.19	0.79	240	15.67	1.00	1.00	0.44
6	1	3,360	10,089	480	18.40	1.00	1.41	0.79	40	15.67	1.00	1.00	0.44
6	2	3,350	10,052	480	18.40	1.00	1.36	0.79	80	15.67	1.00	1.00	0.44
6	3	3,340	10,045	480	18.40	1.00	1.32	0.79	120	15.67	1.00	1.00	0.44
6	4	3,350	10,073	480	18.40	1.00	1.28	0.79	160	15.67	1.00	1.00	0.44
8	1	4,480	13,469	640	18.40	1.00	1.42	0.79	40	15.67	1.00	1.00	0.44
8	2	4,470	13,423	640	18.40	1.00	1.38	0.79	80	15.67	1.00	1.00	0.44
8	3	4,460	13,396	640	18.40	1.00	1.35	0.79	120	15.67	1.00	1.00	0.44
8	4	4,460	13,393	640	18.40	1.00	1.32	0.79	160	15.67	1.00	1.00	0.44

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TABLE 1C - STATIC

SUMMARY - ALLOWABLE BEARING CAPACITY   STRIP FOOTINGS $q_{all} = q_{ult} / FS$

$\phi =$ 30 Effective Stress Friction Angle (degrees)
c = 0 Cohesion (psf)
$\gamma =$ 80 Unit weight of soil (pcf)
$\gamma_{surch} =$ 80 Unit weight of surcharge (pcf)
$\beta =$ 20 Angle of load inclination from vertical (degrees)
FS = 3 Factor of Safety

Assume strip footing if L/B > 5
B = 4 Footing Width (ft)
L = 100 Footing Length (ft)
$D_f =$ 4 Depth of Footing (ft)

D_f ft	B ft	q_{all} psf	q_{ult} = psf	$\gamma_{surch} \cdot D_f$ psf	$\cdot N_q$	$\cdot s_q$	$\cdot d_q$	$\cdot i_q$	$+ ½ \gamma B$	$\cdot N_\gamma$	$\cdot s_\gamma$	$\cdot d_\gamma$	$\cdot i_\gamma$
2.5	1	1,020	3,061	200	18.40	1.00	1.34	0.60	40	15.67	1.00	1.00	0.11
2.5	2	980	2,941	200	18.40	1.00	1.26	0.60	80	15.67	1.00	1.00	0.11
2.5	3	990	2,971	200	18.40	1.00	1.24	0.60	120	15.67	1.00	1.00	0.11
2.5	4	960	2,907	200	18.40	1.00	1.18	0.60	160	15.67	1.00	1.00	0.11
2.5	6	970	2,912	200	18.40	1.00	1.12	0.60	240	15.67	1.00	1.00	0.11
2.5	8	990	2,984	200	18.40	1.00	1.09	0.60	320	15.67	1.00	1.00	0.11
4	1	1,660	4,995	320	18.40	1.00	1.38	0.60	40	15.67	1.00	1.00	0.11
4	2	1,610	4,840	320	18.40	1.00	1.32	0.60	80	15.67	1.00	1.00	0.11
4	3	1,570	4,725	320	18.40	1.00	1.27	0.60	120	15.67	1.00	1.00	0.11
4	4	1,620	4,869	320	18.40	1.00	1.29	0.60	160	15.67	1.00	1.00	0.11
4	6	1,550	4,665	320	18.40	1.00	1.19	0.60	240	15.67	1.00	1.00	0.11
6	1	2,520	7,581	480	18.40	1.00	1.41	0.60	40	15.67	1.00	1.00	0.11
6	2	2,460	7,409	480	18.40	1.00	1.36	0.60	80	15.67	1.00	1.00	0.11
6	3	2,410	7,260	480	18.40	1.00	1.32	0.60	120	15.67	1.00	1.00	0.11
6	4	2,370	7,138	480	18.40	1.00	1.28	0.60	160	15.67	1.00	1.00	0.11
8	1	3,380	10,169	640	18.40	1.00	1.42	0.60	40	15.67	1.00	1.00	0.11
8	2	3,330	9,990	640	18.40	1.00	1.38	0.60	80	15.67	1.00	1.00	0.11
8	3	3,270	9,826	640	18.40	1.00	1.35	0.60	120	15.67	1.00	1.00	0.11
8	4	3,220	9,680	640	18.40	1.00	1.32	0.60	160	15.67	1.00	1.00	0.11

TABLE 2A - STATIC

SUMMARY - ALLOWABLE BEARING CAPACITY   SQUARE FOOTINGS $q_{all} = q_{ult} / FS$

ϕ = 30 Effective Stress Friction Angle (degrees)
c = 0 Cohesion (psf)
γ = 80 Unit weight of soil (pcf)
γ_{surch} = 80 Unit weight of surcharge (pcf)
β = 0 Angle of load inclination from vertical (degrees)
FS = 3 Factor of Safety

B = 4 Footing Width (ft)
L = 4 Footing Length (ft)
D_f = 4 Depth of Footing (ft)

D_f ft	B ft	q_{all} psf	q_{ult} = psf	$\gamma_{surch} \cdot D_f$ psf	• N_q	• s_q	• d_q	• i_q	+ ½ γ B	• N_γ	• s_γ	• d_γ	• i_γ
2.5	1	2,720	8,176	200	18.40	1.58	1.34	1.00	40	15.67	0.60	1.00	1.00
2.5	2	2,680	8,059	200	18.40	1.58	1.26	1.00	80	15.67	0.60	1.00	1.00
2.5	3	2,770	8,330	200	18.40	1.58	1.24	1.00	120	15.67	0.60	1.00	1.00
2.5	4	2,780	8,356	200	18.40	1.58	1.18	1.00	160	15.67	0.60	1.00	1.00
2.5	6	2,910	8,759	200	18.40	1.58	1.12	1.00	240	15.67	0.60	1.00	1.00
2.5	8	3,110	9,337	200	18.40	1.58	1.09	1.00	320	15.67	0.60	1.00	1.00
4	1	4,400	13,219	320	18.40	1.58	1.38	1.00	40	15.67	0.60	1.00	1.00
4	2	4,330	13,009	320	18.40	1.58	1.32	1.00	80	15.67	0.60	1.00	1.00
4	3	4,300	12,902	320	18.40	1.58	1.27	1.00	120	15.67	0.60	1.00	1.00
4	4	4,490	13,473	320	18.40	1.58	1.29	1.00	160	15.67	0.60	1.00	1.00
4	6	4,440	13,332	320	18.40	1.58	1.19	1.00	240	15.67	0.60	1.00	1.00
6	1	6,650	19,961	480	18.40	1.58	1.41	1.00	40	15.67	0.60	1.00	1.00
6	2	6,560	19,708	480	18.40	1.58	1.36	1.00	80	15.67	0.60	1.00	1.00
6	3	6,500	19,513	480	18.40	1.58	1.32	1.00	120	15.67	0.60	1.00	1.00
6	4	6,460	19,389	480	18.40	1.58	1.28	1.00	160	15.67	0.60	1.00	1.00
8	1	8,900	26,708	640	18.40	1.58	1.42	1.00	40	15.67	0.60	1.00	1.00
8	2	8,810	26,438	640	18.40	1.58	1.38	1.00	80	15.67	0.60	1.00	1.00
8	3	8,730	26,204	640	18.40	1.58	1.35	1.00	120	15.67	0.60	1.00	1.00
8	4	8,670	26,017	640	18.40	1.58	1.32	1.00	160	15.67	0.60	1.00	1.00

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TABLE 2B - STATIC

SUMMARY - ALLOWABLE BEARING CAPACITY SQUARE FOOTINGS $q_{all} = q_{ult} / FS$

ϕ = 30 Effective Stress Friction Angle (degrees)
c = 0 Cohesion (psf)
γ = 80 Unit weight of soil (pcf)
γ_{surch} = 80 Unit weight of surcharge (pcf)
β = 10 Angle of load inclination from vertical (degrees)
FS = 3 Factor of Safety

B = 4 Footing Width (ft)
L = 4 Footing Length (ft)
D_f = 4 Depth of Footing (ft)

D_f ft	B ft	q_{all} psf	q_{ult} = psf	$\gamma_{surch} \cdot D_f$ psf	$\cdot N_q$	$\cdot s_q$	$\cdot d_q$	$\cdot i_q$	+ ½ γ B	$\cdot N_\gamma$	$\cdot s_\gamma$	$\cdot d_\gamma$	$\cdot i_\gamma$
2.5	1	2,100	6,330	200	18.40	1.58	1.34	0.79	40	15.67	0.60	1.00	0.44
2.5	2	2,030	6,107	200	18.40	1.58	1.26	0.79	80	15.67	0.60	1.00	0.44
2.5	3	2,060	6,191	200	18.40	1.58	1.24	0.79	120	15.67	0.60	1.00	0.44
2.5	4	2,020	6,083	200	18.40	1.58	1.18	0.79	160	15.67	0.60	1.00	0.44
2.5	6	2,040	6,141	200	18.40	1.58	1.12	0.79	240	15.67	0.60	1.00	0.44
2.5	8	2,110	6,337	200	18.40	1.58	1.09	0.79	320	15.67	0.60	1.00	0.44
4	1	3,430	10,315	320	18.40	1.58	1.38	0.79	40	15.67	0.60	1.00	0.44
4	2	3,330	10,018	320	18.40	1.58	1.32	0.79	80	15.67	0.60	1.00	0.44
4	3	3,260	9,805	320	18.40	1.58	1.27	0.79	120	15.67	0.60	1.00	0.44
4	4	3,370	10,126	320	18.40	1.58	1.29	0.79	160	15.67	0.60	1.00	0.44
4	6	3,250	9,754	320	18.40	1.58	1.19	0.79	240	15.67	0.60	1.00	0.44
6	1	5,210	15,642	480	18.40	1.58	1.41	0.79	40	15.67	0.60	1.00	0.44
6	2	5,100	15,311	480	18.40	1.58	1.36	0.79	80	15.67	0.60	1.00	0.44
6	3	5,000	15,028	480	18.40	1.58	1.32	0.79	120	15.67	0.60	1.00	0.44
6	4	4,930	14,800	480	18.40	1.58	1.28	0.79	160	15.67	0.60	1.00	0.44
8	1	6,990	20,973	640	18.40	1.58	1.42	0.79	40	15.67	0.60	1.00	0.44
8	2	6,870	20,629	640	18.40	1.58	1.38	0.79	80	15.67	0.60	1.00	0.44
8	3	6,770	20,314	640	18.40	1.58	1.35	0.79	120	15.67	0.60	1.00	0.44
8	4	6,670	20,037	640	18.40	1.58	1.32	0.79	160	15.67	0.60	1.00	0.44

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

5010.65

CALCULATION IDENTIFICATION NUMBER			
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE
05996.01	G(B)	07 - 1	

PAGE 15

TABLE 2C - STATIC

SUMMARY - ALLOWABLE BEARING CAPACITY SQUARE FOOTINGS $q_{all} = q_{ult} / FS$

ϕ = 30 Effective Stress Friction Angle (degrees)
c = 0 Cohesion (psf)
γ = 80 Unit weight of soil (pcf)
γ_{surch} = 80 Unit weight of surcharge (pcf)
β = 20 Angle of load inclination from vertical (degrees)
FS = 3 Factor of Safety

B = 4 Footing Width (ft)
L = 4 Footing Length (ft)
D_f = 4 Depth of Footing (ft)

D_f ft	B ft	q_{all} psf	q_{ult} = psf	$\gamma_{surch} \cdot D_f$ psf	$\cdot N_q$	$\cdot s_q$	$\cdot d_q$	$\cdot i_q$	$+ ½ \gamma B$	$\cdot N_\gamma$	$\cdot s_\gamma$	$\cdot d_\gamma$	$\cdot i_\gamma$
2.5	1	1,580	4,760	200	18.40	1.58	1.34	0.60	40	15.67	0.60	1.00	0.11
2.5	2	1,500	4,504	200	18.40	1.58	1.26	0.60	80	15.67	0.60	1.00	0.11
2.5	3	1,490	4,482	200	18.40	1.58	1.24	0.60	120	15.67	0.60	1.00	0.11
2.5	4	1,430	4,312	200	18.40	1.58	1.18	0.60	160	15.67	0.60	1.00	0.11
2.5	6	1,390	4,185	200	18.40	1.58	1.12	0.60	240	15.67	0.60	1.00	0.11
2.5	8	1,380	4,163	200	18.40	1.58	1.09	0.60	320	15.67	0.60	1.00	0.11
4	1	2,600	7,811	320	18.40	1.58	1.38	0.60	40	15.67	0.60	1.00	0.11
4	2	2,490	7,498	320	18.40	1.58	1.32	0.60	80	15.67	0.60	1.00	0.11
4	3	2,410	7,248	320	18.40	1.58	1.27	0.60	120	15.67	0.60	1.00	0.11
4	4	2,460	7,408	320	18.40	1.58	1.29	0.60	160	15.67	0.60	1.00	0.11
4	6	2,310	6,951	320	18.40	1.58	1.19	0.60	240	15.67	0.60	1.00	0.11
6	1	3,960	11,890	480	18.40	1.58	1.41	0.60	40	15.67	0.60	1.00	0.11
6	2	3,850	11,550	480	18.40	1.58	1.36	0.60	80	15.67	0.60	1.00	0.11
6	3	3,740	11,247	480	18.40	1.58	1.32	0.60	120	15.67	0.60	1.00	0.11
6	4	3,660	10,986	480	18.40	1.58	1.28	0.60	160	15.67	0.60	1.00	0.11
8	1	5,320	15,971	640	18.40	1.58	1.42	0.60	40	15.67	0.60	1.00	0.11
8	2	5,200	15,622	640	18.40	1.58	1.38	0.60	80	15.67	0.60	1.00	0.11
8	3	5,090	15,294	640	18.40	1.58	1.35	0.60	120	15.67	0.60	1.00	0.11
8	4	4,990	14,996	640	18.40	1.58	1.32	0.60	160	15.67	0.60	1.00	0.11

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TABLE 3A - DYNAMIC

SUMMARY - ALLOWABLE BEARING CAPACITY **STRIP FOOTINGS** $q_{all} = q_{ult} / FS$

ϕ = 0 Total Stress Friction Angle (degrees)
c = 2200 Cohesion (psf)
γ = 80 Unit weight of soil (pcf)
γ_{surch} = 80 Unit weight of surcharge (pcf)
β = 0 Angle of load inclination from vertical (degrees)
FS = 1.1 Factor of Safety for Dynamic Loads Due to Design Earthquake

Assume strip footing if L/B > 5
B = 4 Footing Width (ft)
L = 100 Footing Length (ft)
D_f = 4 Depth of Footing (ft)

D_f ft	B ft	q_{all} psf	q_{ult} = psf	c psf	• N_c	• s_c	• d_c	• i_c +	γ_{surch} • D_f psf	• N_q	• s_q	• d_q	• i_q
2.5	1	15,350	16,892	2,200	5.14	1.00	1.48	1.00	200	1.00	1.00	1.00	1.00
2.5	2	14,140	15,561	2,200	5.14	1.00	1.36	1.00	200	1.00	1.00	1.00	1.00
2.5	3	13,310	14,650	2,200	5.14	1.00	1.28	1.00	200	1.00	1.00	1.00	1.00
2.5	4	12,750	14,035	2,200	5.14	1.00	1.22	1.00	200	1.00	1.00	1.00	1.00
2.5	6	12,080	13,294	2,200	5.14	1.00	1.16	1.00	200	1.00	1.00	1.00	1.00
2.5	8	11,700	12,878	2,200	5.14	1.00	1.12	1.00	200	1.00	1.00	1.00	1.00
4	1	16,020	17,625	2,200	5.14	1.00	1.53	1.00	320	1.00	1.00	1.00	1.00
4	2	15,120	16,636	2,200	5.14	1.00	1.44	1.00	320	1.00	1.00	1.00	1.00
4	3	14,380	15,822	2,200	5.14	1.00	1.37	1.00	320	1.00	1.00	1.00	1.00
4	4	13,800	15,181	2,200	5.14	1.00	1.31	1.00	320	1.00	1.00	1.00	1.00
4	6	12,980	14,288	2,200	5.14	1.00	1.24	1.00	320	1.00	1.00	1.00	1.00
6	1	16,490	18,146	2,200	5.14	1.00	1.56	1.00	480	1.00	1.00	1.00	1.00
6	2	15,850	17,438	2,200	5.14	1.00	1.50	1.00	480	1.00	1.00	1.00	1.00
6	3	15,260	16,796	2,200	5.14	1.00	1.44	1.00	480	1.00	1.00	1.00	1.00
6	4	14,750	16,233	2,200	5.14	1.00	1.39	1.00	480	1.00	1.00	1.00	1.00
8	1	16,800	18,491	2,200	5.14	1.00	1.58	1.00	640	1.00	1.00	1.00	1.00
8	2	16,310	17,945	2,200	5.14	1.00	1.53	1.00	640	1.00	1.00	1.00	1.00
8	3	15,840	17,430	2,200	5.14	1.00	1.48	1.00	640	1.00	1.00	1.00	1.00
8	4	15,410	16,956	2,200	5.14	1.00	1.44	1.00	640	1.00	1.00	1.00	1.00

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TABLE 3B - DYNAMIC

SUMMARY - ALLOWABLE BEARING CAPACITY STRIP FOOTINGS $q_{all} = q_{ult} / FS$

ϕ = 0 Total Stress Friction Angle (degrees)
c = 2200 Cohesion (psf)
γ = 80 Unit weight of soil (pcf)
γ_{surch} = 80 Unit weight of surcharge (pcf)
β = 10 Angle of load inclination from vertical (degrees)
FS = 1.1 Factor of Safety for Dynamic Loads Due to Design Earthquake

Assume strip footing if L/B > 5
B = 4 Footing Width (ft)
L = 100 Footing Length (ft)
D_f = 4 Depth of Footing (ft)

D_f ft	B ft	q_{all} psf	q_{ult} = psf	c psf	• N_c	• s_c	• d_c	• i_c +	γ_{surch} • D_f psf	• N_q	• s_q	• d_q	• i_q
2.5	1	12,130	13,347	2,200	5.14	1.00	1.48	0.79	200	1.00	1.00	1.00	0.79
2.5	2	11,170	12,295	2,200	5.14	1.00	1.36	0.79	200	1.00	1.00	1.00	0.79
2.5	3	10,520	11,576	2,200	5.14	1.00	1.28	0.79	200	1.00	1.00	1.00	0.79
2.5	4	10,080	11,089	2,200	5.14	1.00	1.22	0.79	200	1.00	1.00	1.00	0.79
2.5	6	9,540	10,504	2,200	5.14	1.00	1.16	0.79	200	1.00	1.00	1.00	0.79
2.5	8	9,250	10,175	2,200	5.14	1.00	1.12	0.79	200	1.00	1.00	1.00	0.79
4	1	12,650	13,926	2,200	5.14	1.00	1.53	0.79	320	1.00	1.00	1.00	0.79
4	2	11,940	13,144	2,200	5.14	1.00	1.44	0.79	320	1.00	1.00	1.00	0.79
4	3	11,360	12,502	2,200	5.14	1.00	1.37	0.79	320	1.00	1.00	1.00	0.79
4	4	10,900	11,994	2,200	5.14	1.00	1.31	0.79	320	1.00	1.00	1.00	0.79
4	6	10,260	11,289	2,200	5.14	1.00	1.24	0.79	320	1.00	1.00	1.00	0.79
6	1	13,030	14,338	2,200	5.14	1.00	1.56	0.79	480	1.00	1.00	1.00	0.79
6	2	12,520	13,778	2,200	5.14	1.00	1.50	0.79	480	1.00	1.00	1.00	0.79
6	3	12,060	13,271	2,200	5.14	1.00	1.44	0.79	480	1.00	1.00	1.00	0.79
6	4	11,660	12,826	2,200	5.14	1.00	1.39	0.79	480	1.00	1.00	1.00	0.79
8	1	13,280	14,610	2,200	5.14	1.00	1.58	0.79	640	1.00	1.00	1.00	0.79
8	2	12,880	14,179	2,200	5.14	1.00	1.53	0.79	640	1.00	1.00	1.00	0.79
8	3	12,520	13,772	2,200	5.14	1.00	1.48	0.79	640	1.00	1.00	1.00	0.79
8	4	12,170	13,397	2,200	5.14	1.00	1.44	0.79	640	1.00	1.00	1.00	0.79

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TABLE 3C — DYNAMIC

SUMMARY - ALLOWABLE BEARING CAPACITY **STRIP FOOTINGS** $q_{all} = q_{ult} / FS$

ϕ = 0 Total Stress Friction Angle (degrees)
c = 2200 Cohesion (psf)
γ = 80 Unit weight of soil (pcf)
γ_{surch} = 80 Unit weight of surcharge (pcf)
β = 20 Angle of load inclination from vertical (degrees)
FS = 1.1 Factor of Safety for Dynamic Loads Due to Design Earthquake

Assume strip footing if L/B > 5
B = 4 Footing Width (ft)
L = 100 Footing Length (ft)
D_f = 4 Depth of Footing (ft)

D_f ft	B ft	q_{all} psf	q_{ult} = psf	c psf	• N_c	• s_c	• d_c	• i_c +	γ_{surch} • D_f psf	• N_q	• s_q	• d_q	• i_q
2.5	1	9,280	10,219	2,200	5.14	1.00	1.48	0.60	200	1.00	1.00	1.00	0.60
2.5	2	8,550	9,413	2,200	5.14	1.00	1.36	0.60	200	1.00	1.00	1.00	0.60
2.5	3	8,050	8,863	2,200	5.14	1.00	1.28	0.60	200	1.00	1.00	1.00	0.60
2.5	4	7,710	8,490	2,200	5.14	1.00	1.22	0.60	200	1.00	1.00	1.00	0.60
2.5	6	7,310	8,042	2,200	5.14	1.00	1.16	0.60	200	1.00	1.00	1.00	0.60
2.5	8	7,080	7,790	2,200	5.14	1.00	1.12	0.60	200	1.00	1.00	1.00	0.60
4	1	9,690	10,662	2,200	5.14	1.00	1.53	0.60	320	1.00	1.00	1.00	0.60
4	2	9,140	10,064	2,200	5.14	1.00	1.44	0.60	320	1.00	1.00	1.00	0.60
4	3	8,700	9,572	2,200	5.14	1.00	1.37	0.60	320	1.00	1.00	1.00	0.60
4	4	8,340	9,183	2,200	5.14	1.00	1.31	0.60	320	1.00	1.00	1.00	0.60
4	6	7,850	8,643	2,200	5.14	1.00	1.24	0.60	320	1.00	1.00	1.00	0.60
6	1	9,970	10,977	2,200	5.14	1.00	1.56	0.60	480	1.00	1.00	1.00	0.60
6	2	9,580	10,549	2,200	5.14	1.00	1.50	0.60	480	1.00	1.00	1.00	0.60
6	3	9,230	10,160	2,200	5.14	1.00	1.44	0.60	480	1.00	1.00	1.00	0.60
6	4	8,920	9,820	2,200	5.14	1.00	1.39	0.60	480	1.00	1.00	1.00	0.60
8	1	10,160	11,186	2,200	5.14	1.00	1.58	0.60	640	1.00	1.00	1.00	0.60
8	2	9,860	10,856	2,200	5.14	1.00	1.53	0.60	640	1.00	1.00	1.00	0.60
8	3	9,580	10,544	2,200	5.14	1.00	1.48	0.60	640	1.00	1.00	1.00	0.60
8	4	9,320	10,257	2,200	5.14	1.00	1.44	0.60	640	1.00	1.00	1.00	0.60

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TABLE 4A - DYNAMIC

SUMMARY - ALLOWABLE BEARING CAPACITY SQUARE FOOTINGS $q_{all} = q_{ult} / FS$

ϕ = 0 Total Stress Friction Angle (degrees)
c = 2200 Cohesion (psf)
γ = 80 Unit weight of soil (pcf)
γ_{surch} = 80 Unit weight of surcharge (pcf)
β = 0 Angle of load inclination from vertical (degrees)
FS = 1.1 Factor of Safety for Dynamic Loads Due to Design Earthquake

B = 4 Footing Width (ft)
L = 4 Footing Length (ft)
D_f = 4 Depth of Footing (ft)

D_f ft	B ft	q_{all} psf	q_{ult} = psf	c psf	• N_c	• s_c	• d_c	• i_c +	γ_{surch} • D_f psf	• N_q	• s_q	• d_q	• i_q
2.5	1	18,300	20,139	2,200	5.14	1.19	1.48	1.00	200	1.00	1.00	1.00	1.00
2.5	2	16,860	18,550	2,200	5.14	1.19	1.36	1.00	200	1.00	1.00	1.00	1.00
2.5	3	15,870	17,462	2,200	5.14	1.19	1.28	1.00	200	1.00	1.00	1.00	1.00
2.5	4	15,200	16,726	2,200	5.14	1.19	1.22	1.00	200	1.00	1.00	1.00	1.00
2.5	6	14,400	15,841	2,200	5.14	1.19	1.16	1.00	200	1.00	1.00	1.00	1.00
2.5	8	13,940	15,345	2,200	5.14	1.19	1.12	1.00	200	1.00	1.00	1.00	1.00
4	1	19,080	20,992	2,200	5.14	1.19	1.53	1.00	320	1.00	1.00	1.00	1.00
4	2	18,000	19,810	2,200	5.14	1.19	1.44	1.00	320	1.00	1.00	1.00	1.00
4	3	17,120	18,838	2,200	5.14	1.19	1.37	1.00	320	1.00	1.00	1.00	1.00
4	4	16,420	18,072	2,200	5.14	1.19	1.31	1.00	320	1.00	1.00	1.00	1.00
4	6	15,450	17,005	2,200	5.14	1.19	1.24	1.00	320	1.00	1.00	1.00	1.00
6	1	19,620	21,583	2,200	5.14	1.19	1.56	1.00	480	1.00	1.00	1.00	1.00
6	2	18,850	20,737	2,200	5.14	1.19	1.50	1.00	480	1.00	1.00	1.00	1.00
6	3	18,150	19,970	2,200	5.14	1.19	1.44	1.00	480	1.00	1.00	1.00	1.00
6	4	17,540	19,298	2,200	5.14	1.19	1.39	1.00	480	1.00	1.00	1.00	1.00
8	1	19,960	21,963	2,200	5.14	1.19	1.58	1.00	640	1.00	1.00	1.00	1.00
8	2	19,370	21,312	2,200	5.14	1.19	1.53	1.00	640	1.00	1.00	1.00	1.00
8	3	18,810	20,697	2,200	5.14	1.19	1.48	1.00	640	1.00	1.00	1.00	1.00
8	4	18,300	20,130	2,200	5.14	1.19	1.44	1.00	640	1.00	1.00	1.00	1.00

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TABLE 4B - DYNAMIC

SUMMARY - ALLOWABLE BEARING CAPACITY   SQUARE FOOTINGS $q_{all} = q_{ult} / FS$

ϕ = 0 Total Stress Friction Angle (degrees)
c = 2200 Cohesion (psf)
γ = 80 Unit weight of soil (pcf)
γ_{surch} = 80 Unit weight of surcharge (pcf)
β = 10 Angle of load inclination from vertical (degrees)
FS = 1.1 Factor of Safety for Dynamic Loads Due to Design Earthquake

B = 4 Footing Width (ft)
L = 4 Footing Length (ft)
D_f = 4 Depth of Footing (ft)

D_f ft	B ft	q_{all} psf	q_{ult} = psf	c psf	• N_c	• s_c	• d_c	• I_c +	γ_{surch} • D_f psf	• N_q	• s_q	• d_q	• I_q
2.5	1	14,460	15,913	2,200	5.14	1.19	1.48	0.79	200	1.00	1.00	1.00	0.79
2.5	2	13,320	14,656	2,200	5.14	1.19	1.36	0.79	200	1.00	1.00	1.00	0.79
2.5	3	12,540	13,797	2,200	5.14	1.19	1.28	0.79	200	1.00	1.00	1.00	0.79
2.5	4	12,010	13,216	2,200	5.14	1.19	1.22	0.79	200	1.00	1.00	1.00	0.79
2.5	6	11,370	12,516	2,200	5.14	1.19	1.16	0.79	200	1.00	1.00	1.00	0.79
2.5	8	11,020	12,124	2,200	5.14	1.19	1.12	0.79	200	1.00	1.00	1.00	0.79
4	1	15,070	16,586	2,200	5.14	1.19	1.53	0.79	320	1.00	1.00	1.00	0.79
4	2	14,220	15,652	2,200	5.14	1.19	1.44	0.79	320	1.00	1.00	1.00	0.79
4	3	13,530	14,885	2,200	5.14	1.19	1.37	0.79	320	1.00	1.00	1.00	0.79
4	4	12,980	14,279	2,200	5.14	1.19	1.31	0.79	320	1.00	1.00	1.00	0.79
4	6	12,210	13,436	2,200	5.14	1.19	1.24	0.79	320	1.00	1.00	1.00	0.79
6	1	15,500	17,053	2,200	5.14	1.19	1.56	0.79	480	1.00	1.00	1.00	0.79
6	2	14,890	16,385	2,200	5.14	1.19	1.50	0.79	480	1.00	1.00	1.00	0.79
6	3	14,340	15,779	2,200	5.14	1.19	1.44	0.79	480	1.00	1.00	1.00	0.79
6	4	13,860	15,248	2,200	5.14	1.19	1.39	0.79	480	1.00	1.00	1.00	0.79
8	1	15,770	17,354	2,200	5.14	1.19	1.58	0.79	640	1.00	1.00	1.00	0.79
8	2	15,300	16,839	2,200	5.14	1.19	1.53	0.79	640	1.00	1.00	1.00	0.79
8	3	14,860	16,353	2,200	5.14	1.19	1.48	0.79	640	1.00	1.00	1.00	0.79
8	4	14,450	15,905	2,200	5.14	1.19	1.44	0.79	640	1.00	1.00	1.00	0.79

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05996.01	G(B)	07 - 1		21

CALCULATION IDENTIFICATION NUMBER

5010.65

TABLE 4C – DYNAMIC

SUMMARY - ALLOWABLE BEARING CAPACITY   SQUARE FOOTINGS $q_{all} = q_{ult} / FS$

ϕ = 0 Total Stress Friction Angle (degrees)

c = 2200 Cohesion (psf)

γ = 80 Unit weight of soil (pcf)

γ_{surch} = 80 Unit weight of surcharge (pcf)

β = 20 Angle of load inclination from vertical (degrees)

FS = 1.1 Factor of Safety for Dynamic Loads Due to Design Earthquake

B = 4 Footing Width (ft)

L = 4 Footing Length (ft)

D_f = 4 Depth of Footing (ft)

D_f ft	B ft	q_{all} psf	q_{ult} = psf	c psf	• N_c	• s_c	• d_c	• i_c +	γ_{surch} • D_f psf	• N_q	• s_q	• d_q	• i_q
2.5	1	11,070	12,183	2,200	5.14	1.19	1.48	0.60	200	1.00	1.00	1.00	0.60
2.5	2	10,200	11,221	2,200	5.14	1.19	1.36	0.60	200	1.00	1.00	1.00	0.60
2.5	3	9,600	10,563	2,200	5.14	1.19	1.28	0.60	200	1.00	1.00	1.00	0.60
2.5	4	9,190	10,118	2,200	5.14	1.19	1.22	0.60	200	1.00	1.00	1.00	0.60
2.5	6	8,710	9,583	2,200	5.14	1.19	1.16	0.60	200	1.00	1.00	1.00	0.60
2.5	8	8,430	9,283	2,200	5.14	1.19	1.12	0.60	200	1.00	1.00	1.00	0.60
4	1	11,540	12,699	2,200	5.14	1.19	1.53	0.60	320	1.00	1.00	1.00	0.60
4	2	10,890	11,984	2,200	5.14	1.19	1.44	0.60	320	1.00	1.00	1.00	0.60
4	3	10,360	11,396	2,200	5.14	1.19	1.37	0.60	320	1.00	1.00	1.00	0.60
4	4	9,930	10,932	2,200	5.14	1.19	1.31	0.60	320	1.00	1.00	1.00	0.60
4	6	9,350	10,287	2,200	5.14	1.19	1.24	0.60	320	1.00	1.00	1.00	0.60
6	1	11,860	13,056	2,200	5.14	1.19	1.56	0.60	480	1.00	1.00	1.00	0.60
6	2	11,400	12,545	2,200	5.14	1.19	1.50	0.60	480	1.00	1.00	1.00	0.60
6	3	10,980	12,081	2,200	5.14	1.19	1.44	0.60	480	1.00	1.00	1.00	0.60
6	4	10,610	11,674	2,200	5.14	1.19	1.39	0.60	480	1.00	1.00	1.00	0.60
8	1	12,070	13,287	2,200	5.14	1.19	1.58	0.60	640	1.00	1.00	1.00	0.60
8	2	11,720	12,892	2,200	5.14	1.19	1.53	0.60	640	1.00	1.00	1.00	0.60
8	3	11,380	12,520	2,200	5.14	1.19	1.48	0.60	640	1.00	1.00	1.00	0.60
8	4	11,070	12,177	2,200	5.14	1.19	1.44	0.60	640	1.00	1.00	1.00	0.60

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CALCULATION IDENTIFICATION NUMBER				PAGE 22
J.O. OR W.O. NO. 05996.01	DIVISION & GROUP G(B)	CALCULATION NO. 07-1	OPTIONAL TASK CODE	

TABLE 5

SUMMARY OF GROSS ALLOWABLE BEARING PRESSURES FOR VARIOUS WIDTHS AND DEPTHS OF STRIP FOOTINGS TO OBTAIN < 2 INCHES OF SETTLEMENT

D	B	q	$\rho_{elastic}$	$\rho_{primary}$	Secondary Settlement			Total Settlement		
					1 month	20 yrs	40 yrs	ρ_{immed}	$\rho_{1\ month}$	$\rho_{40\ yr}$
ft	ft	ksf	in.	in.	in.	in.	in.	in.	in.	in.
2.50	7.00	**1.85**	0.10	1.12	0.51	0.77	0.80	1.21	1.72	**2.01**
2.50	8.00	**1.70**	0.09	1.11	0.51	0.77	0.80	1.20	1.71	**2.00**
2.50	10.00	**1.50**	0.09	1.10	0.51	0.77	0.80	1.18	1.69	**1.98**
4.00	5.30	**2.90**	0.19	1.12	0.44	0.67	0.70	1.32	1.76	**2.01**
4.00	6.00	**2.50**	0.13	1.09	0.48	0.73	0.76	1.23	1.71	**1.99**
4.00	7.00	**2.20**	0.12	1.08	0.52	0.79	0.83	1.20	1.72	**2.02**
4.00	8.00	**2.00**	0.11	1.06	0.52	0.78	0.81	1.17	1.68	**1.98**
4.00	10.00	**1.80**	0.10	1.06	0.52	0.78	0.82	1.17	1.68	**1.98**
6.00	3.70	**4.30**	0.40	0.98	0.41	0.61	0.64	1.39	1.79	**2.03**
6.00	5.00	**3.30**	0.22	1.01	0.47	0.71	0.74	1.24	1.71	**1.98**
6.00	6.00	**2.80**	0.15	1.01	0.53	0.81	0.84	1.16	1.70	**2.00**
6.00	8.00	**2.40**	0.13	1.01	0.54	0.81	0.85	1.14	1.68	**1.99**
6.00	10.00	**2.20**	0.13	1.02	0.54	0.82	0.85	1.15	1.69	**2.00**
8.00	2.60	**5.75**	0.49	0.80	0.47	0.71	0.74	1.29	1.76	**2.03**
8.00	5.00	**3.60**	0.24	0.94	0.52	0.78	0.82	1.18	1.70	**2.00**
8.00	6.00	**3.10**	0.18	0.93	0.55	0.83	0.86	1.11	1.66	**1.97**
8.00	7.00	**2.90**	0.16	0.94	0.55	0.83	0.87	1.10	1.65	**1.97**
8.00	8.00	**2.80**	0.16	0.97	0.56	0.84	0.88	1.13	1.69	**2.01**
8.00	10.00	**2.55**	0.15	0.97	0.56	0.85	0.88	1.12	1.68	**2.00**

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TABLE 6

SUMMARY OF GROSS ALLOWABLE BEARING PRESSURES FOR VARIOUS WIDTHS AND DEPTHS OF SQUARE FOOTINGS TO OBTAIN ≤ 1.5 INCHES OF SETTLEMENT

D	B	q	$\rho_{elastic}$	$\rho_{primary}$	Secondary Settlement			Total Settlement		
					1 month	20 yrs	40 yrs	ρ_{immed}	$\rho_{1\ month}$	$\rho_{40\ yr}$
ft	ft	ksf	in.	in.	in.	in.	in.	in.	in.	in.
2.50	5.10	**2.70**	0.10	0.86	0.34	0.51	0.53	0.96	1.30	**1.49**
2.50	6.00	**2.20**	0.07	0.84	0.39	0.59	0.62	0.91	1.30	**1.52**
2.50	8.00	**1.50**	0.05	0.76	0.45	0.69	0.72	0.81	1.26	**1.53**
2.50	10.00	**1.20**	0.04	0.72	0.46	0.69	0.72	0.76	1.22	**1.48**
4.00	3.80	**4.30**	0.32	0.78	0.26	0.40	0.41	1.10	1.36	**1.51**
4.00	6.00	**2.90**	0.15	0.85	0.33	0.50	0.52	0.99	1.32	**1.51**
4.00	8.00	**2.00**	0.07	0.79	0.41	0.62	0.65	0.86	1.27	**1.51**
4.00	10.00	**1.60**	0.06	0.75	0.45	0.68	0.71	0.81	1.26	**1.52**
6.00	2.20	**6.50**	0.32	0.57	0.39	0.59	0.62	0.89	1.27	**1.50**
6.00	3.00	**5.40**	0.33	0.65	0.34	0.52	0.54	0.98	1.32	**1.52**
6.00	4.00	**4.50**	0.34	0.71	0.30	0.46	0.48	1.05	1.35	**1.52**
6.00	6.00	**3.40**	0.19	0.79	0.32	0.49	0.51	0.98	1.30	**1.49**
6.00	8.00	**2.60**	0.11	0.79	0.39	0.59	0.61	0.90	1.29	**1.51**
6.00	10.00	**2.00**	0.07	0.73	0.45	0.68	0.71	0.81	1.26	**1.52**
8.00	1.30	**8.70**	0.30	0.64	0.35	0.53	0.55	0.94	1.29	**1.49**
8.00	2.00	**6.80**	0.30	0.57	0.40	0.61	0.63	0.87	1.27	**1.50**
8.00	3.00	**5.60**	0.34	0.58	0.38	0.58	0.60	0.91	1.29	**1.51**
8.00	4.00	**4.70**	0.34	0.64	0.33	0.50	0.53	0.98	1.31	**1.51**
8.00	6.00	**3.50**	0.19	0.71	0.40	0.60	0.63	0.89	1.29	**1.52**
8.00	8.00	**2.70**	0.10	0.70	0.46	0.70	0.73	0.80	1.26	**1.52**
8.00	10.00	**2.30**	0.08	0.69	0.45	0.68	0.71	0.77	1.22	**1.48**

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STONE & WEBSTER ENGINEERING CORPORATION

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CALCULATION IDENTIFICATION NUMBER				PAGE 24
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	
05996.01	G(B)	07 - 1		

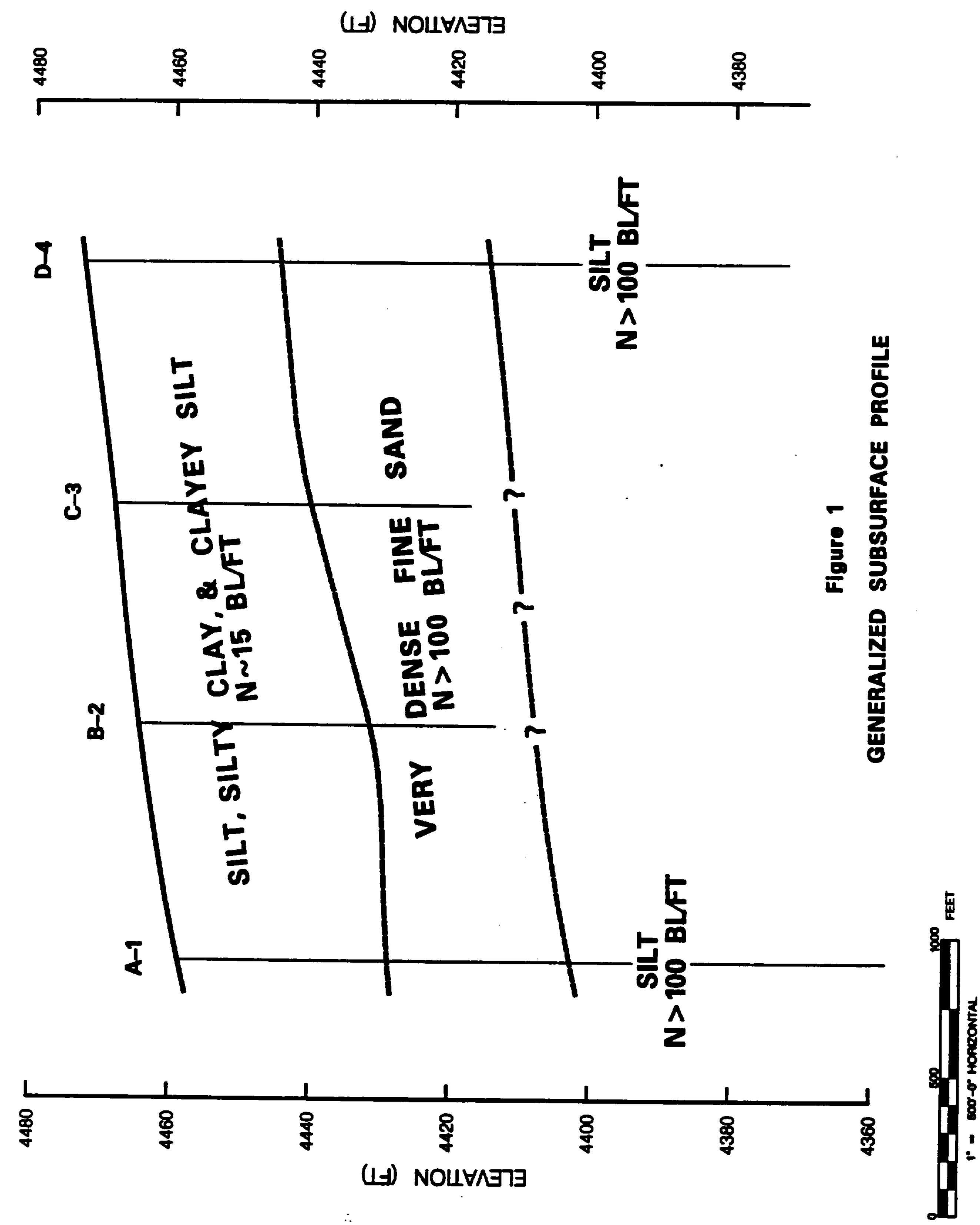
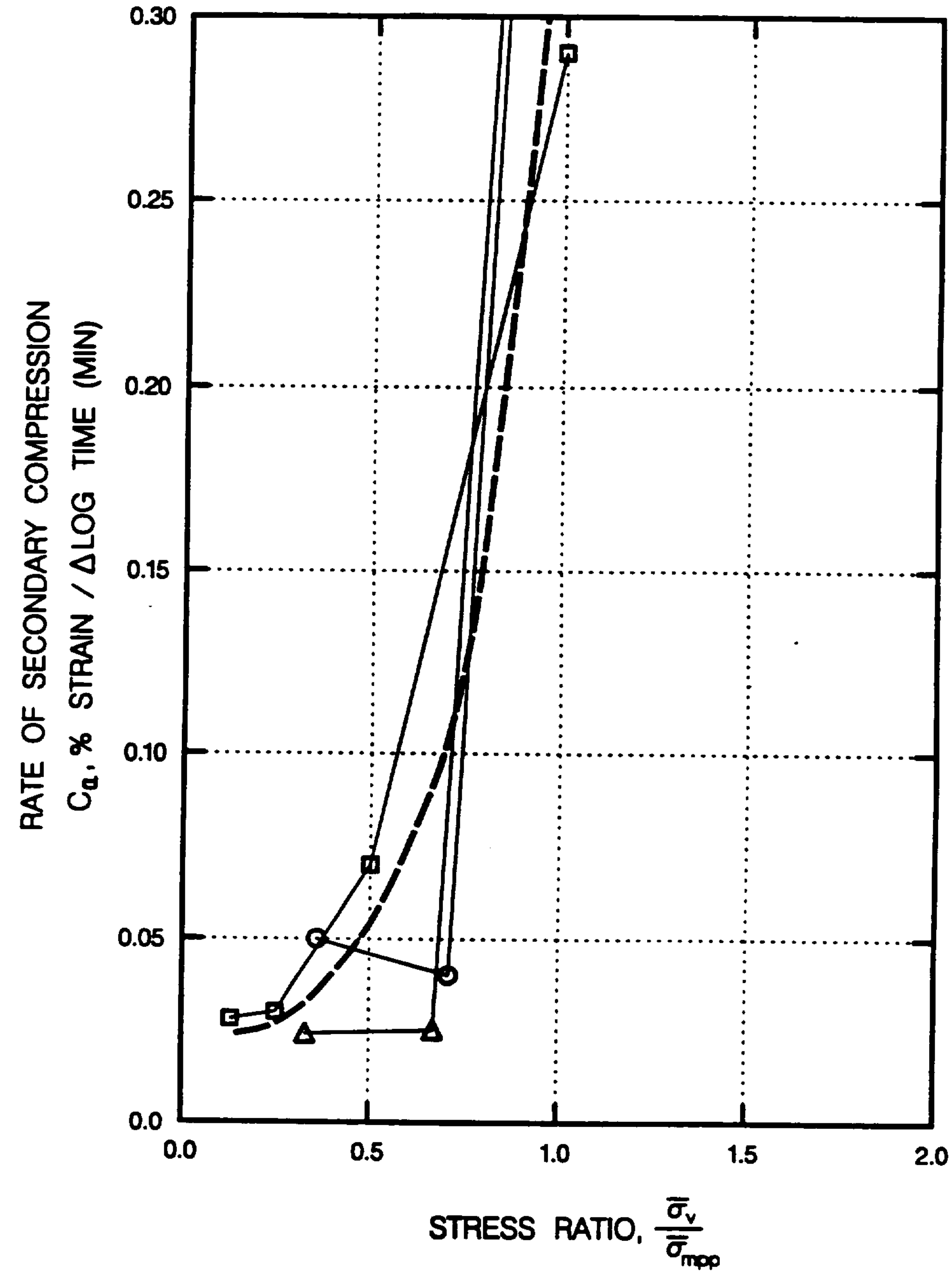


Figure 1

GENERALIZED SUBSURFACE PROFILE



KEY

SYMBOL	TEST ID
O	C1-U3C
□	C1-U3D
Δ	C2-U2C

Figure 2

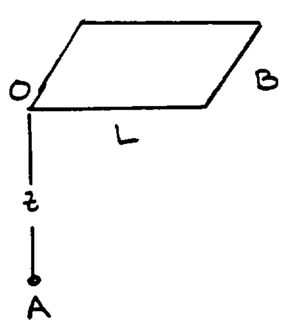
RATE OF SECONDARY COMPRESSION VS STRESS RATIO

BASED ON RELOADING PORTIONS OF CONSOLIDATION TESTS - SEE CALC 05996.01-G(B)-05-0.

CALCULATION IDENTIFICATION NUMBER				PAGE 26
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	
05996.01	G(B)	07-1		

FIGURE 3

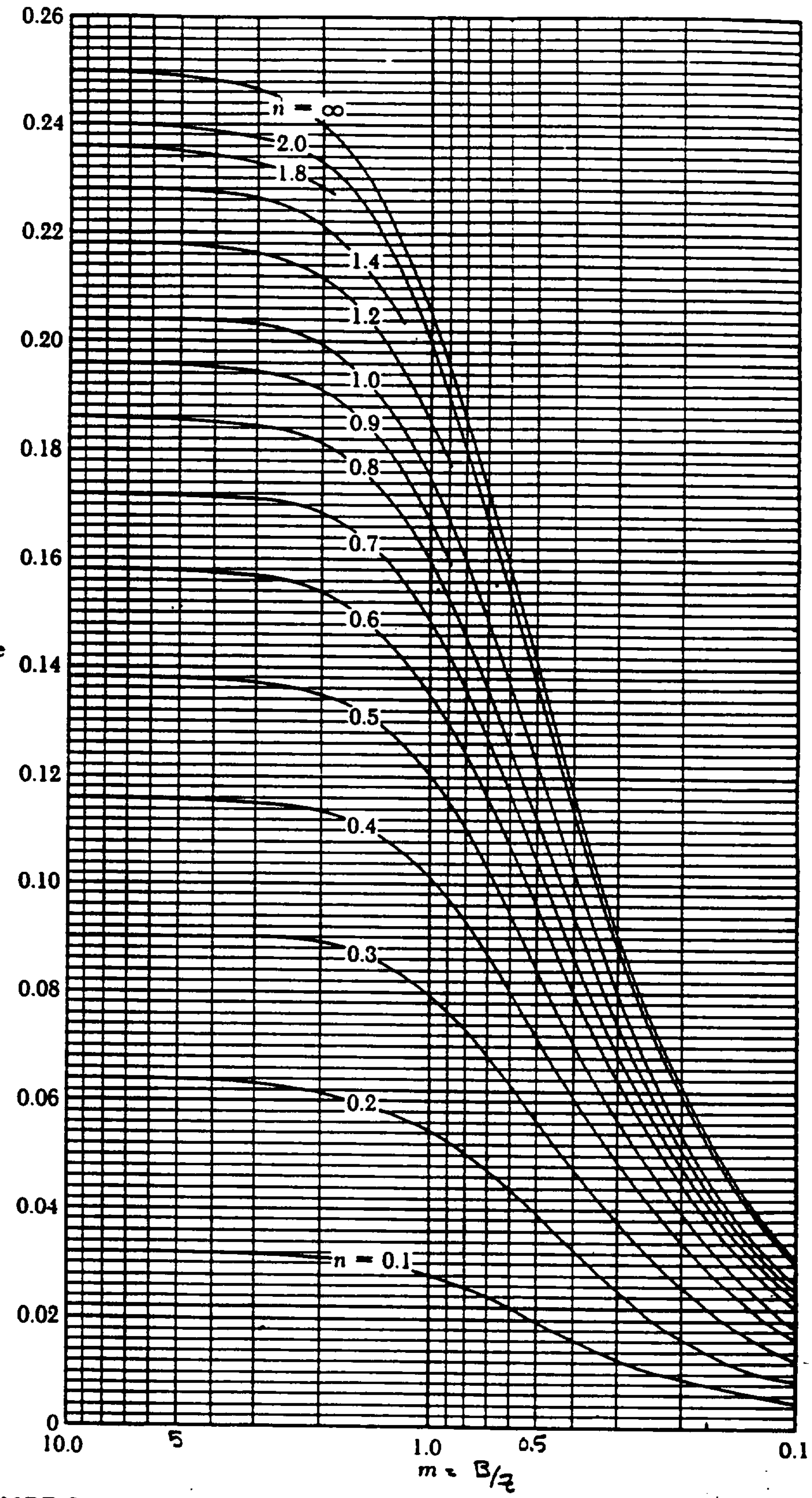
INFLUENCE VALUE FOR DET'G STRESSES WITH RESPECT TO DEPTH



$\Delta p_A = q_0 I$

$m = B/z$

$n = L/z$



DAS (1995) ▼ **FIGURE 3.40** Variation of I with m and n—Eqs. (3.103) and (3.104)

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CALCULATION IDENTIFICATION NUMBER				PAGE 27
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	
05996.01	G(B)	07 - 1		

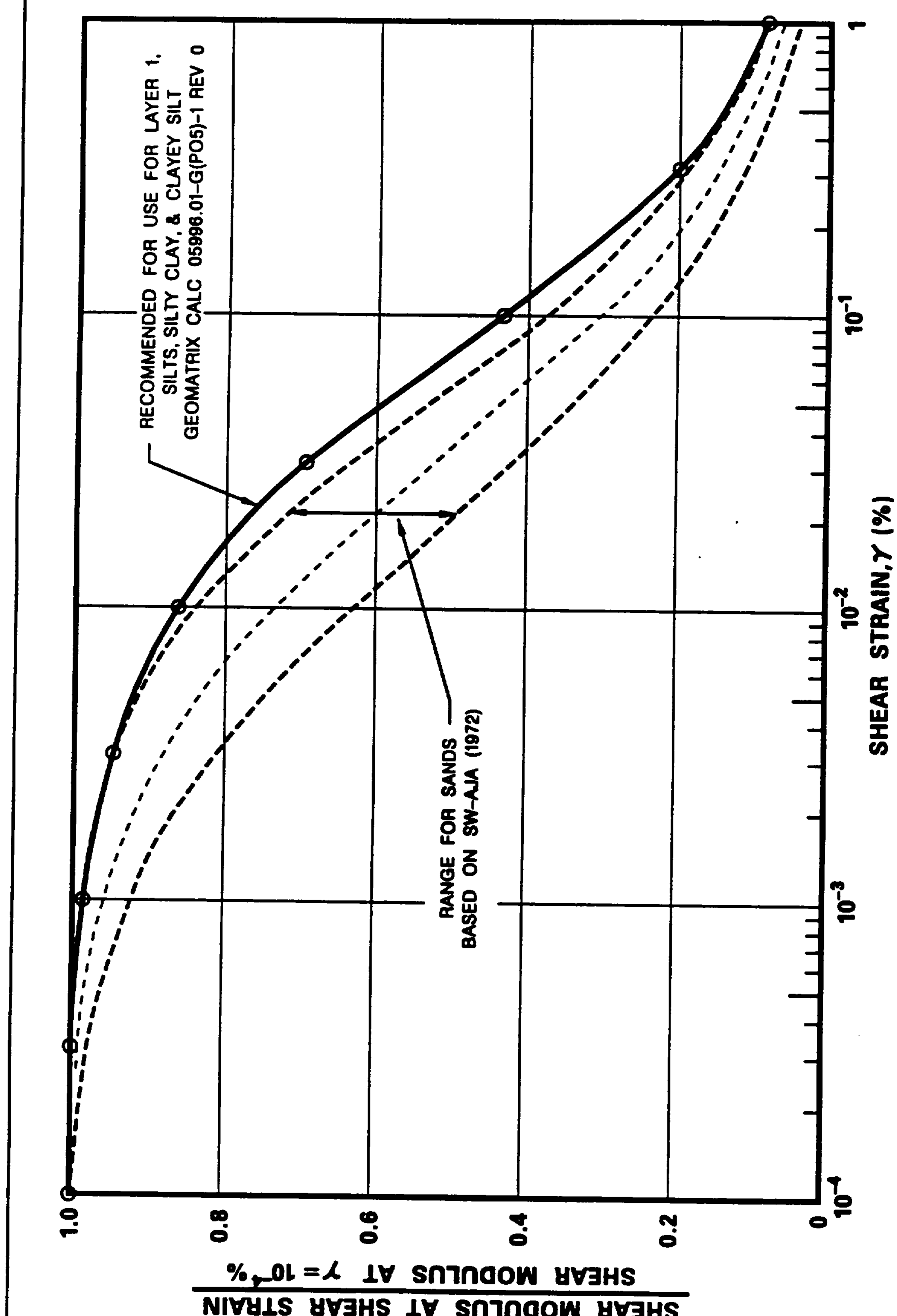
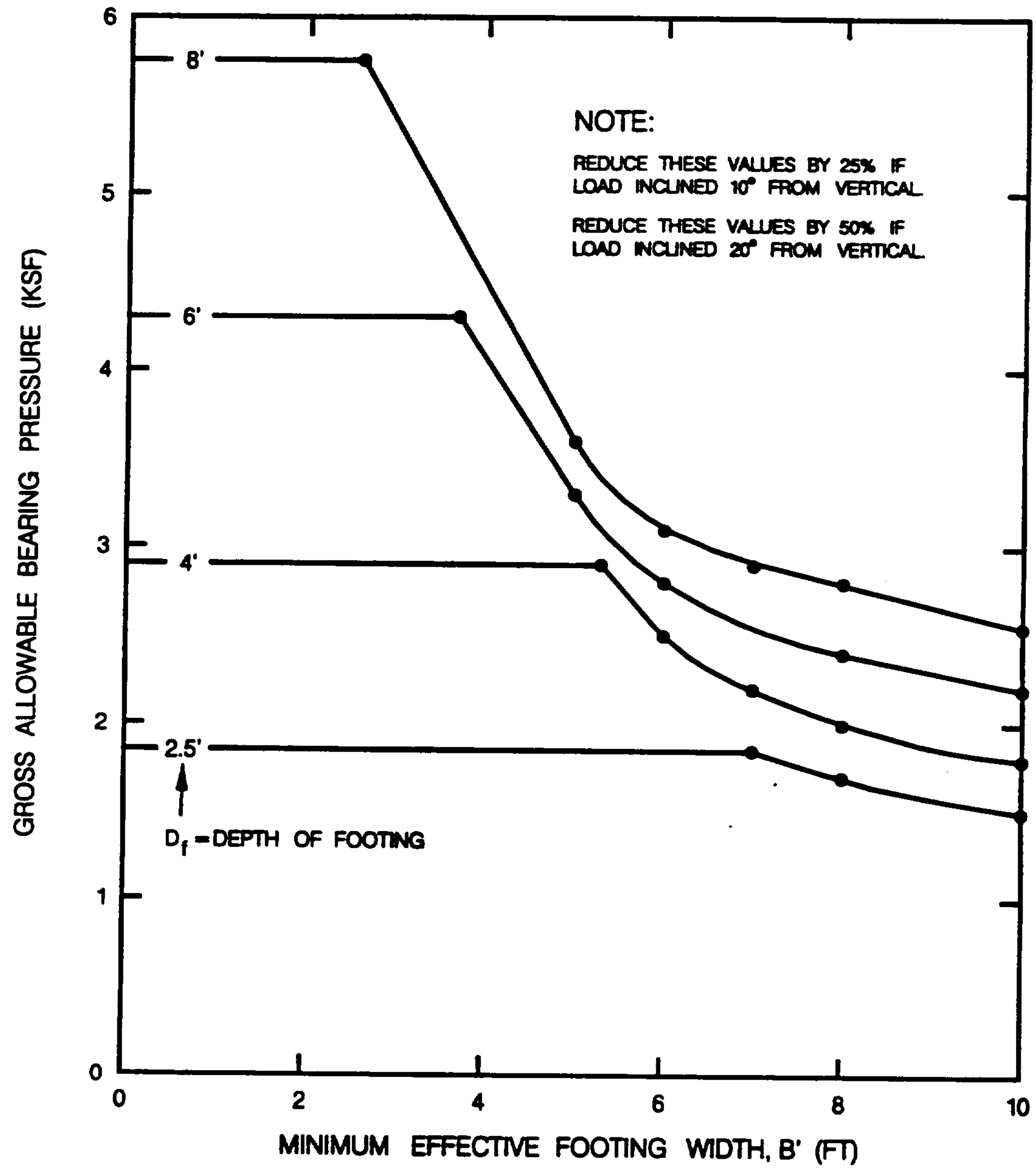
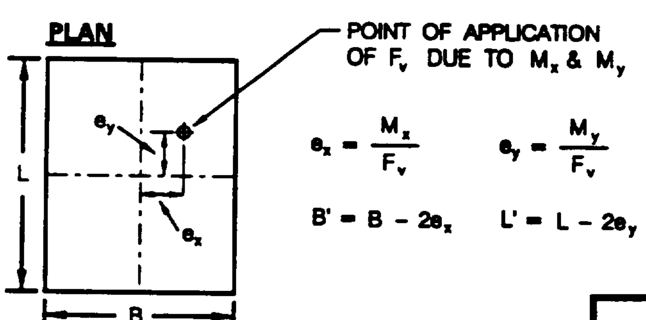
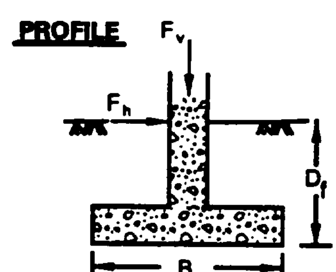


Figure 4

VARIATION OF SHEAR MODULUS WITH SHEAR STRAIN







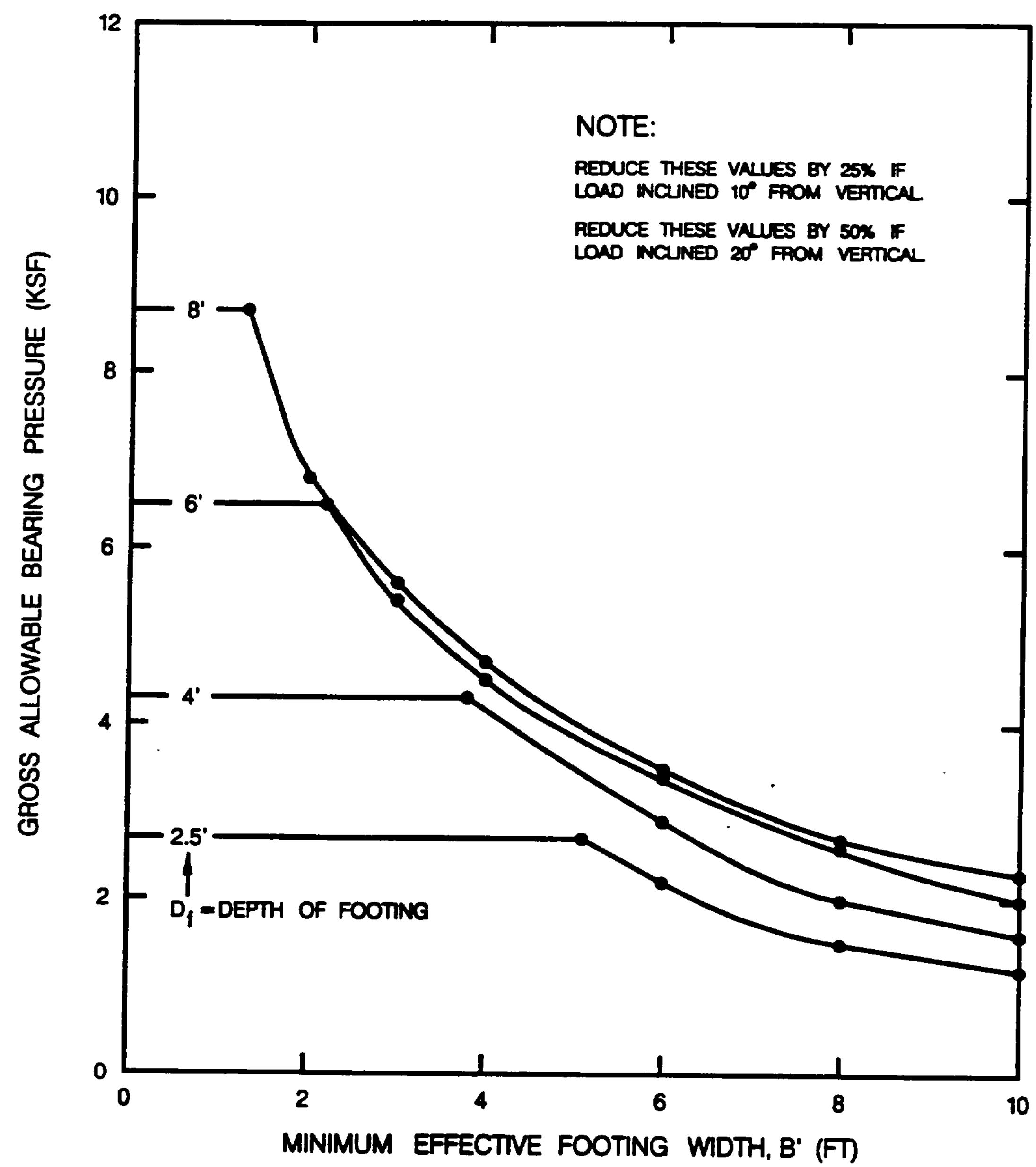
BASED ON MAXIMUM ALLOWABLE SETTLEMENT = 2" @ 40 YRS USING STRAIN-COMPATIBLE MODULI RECOMMENDED BY GEOMATRIX (1997)

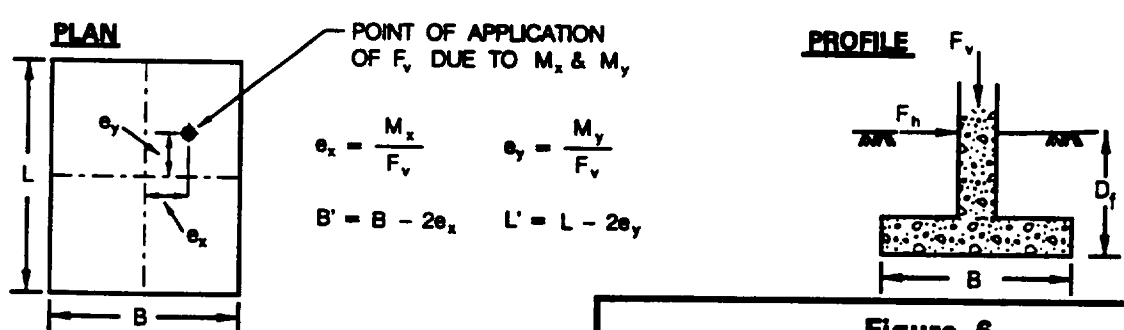
Figure 5

GROSS ALLOWABLE BEARING PRESSURE VS FOOTING WIDTH & DEPTH FOR STRIP FOOTINGS

PRIVATE FUEL STORAGE ISFSI

CALC 05996.01-G(B)-07-1 p 28





BASED ON MAXIMUM ALLOWABLE SETTLEMENT = 1.5" @ 40 YRS USING STRAIN-COMPATIBLE MODULI RECOMMENDED BY GEOMATRIX (1997)

Figure 6

GROSS ALLOWABLE BEARING PRESSURE VS FOOTING WIDTH & DEPTH FOR SQUARE FOOTINGS

PRIVATE FUEL STORAGE ISFSI

CALC 05996.01-G(B)-07-1 p 29

APPENDIX A - STATIC

ALLOWABLE BEARING CAPACITY STRIP FOOTING

Soil Properties:	ϕ =	30	Effective Stress Friction Angle (degrees)
	c =	0	Cohesion (psf)
	γ =	80	Unit weight of soil (pcf)
	γ_{surch} =	80	Unit weight of surcharge (pcf)
Foundation Properties:	B =	4	Footing Width (ft) L = 100.00 ft
	D_f =	4	Depth of Footing (ft) **Assume strip footing if L/B > 5**
	β =	0	Angle of load inclination from vertical (degrees)
	FS =	3	Factor of Safety

$$q_{ult} = c\, N_c\, s_c\, d_c\, i_c + \gamma\, D_f\, N_q\, s_q\, d_q\, i_q + 1/2\, \gamma\, B\, N_\gamma\, s_\gamma\, d_\gamma\, i_\gamma$$ **Meyerhoff General Bearing Capacity**

	$N_c = (N_q - 1)\cot(\phi)$	=	30.14	Eq 2-8 Bowles (1968)
	$N_q = e^{\pi \tan\phi} \tan^2(45 + \phi/2)$	=	18.40	Eq 10.32 Das (1990)
	$N_\gamma = (N_q - 1)\tan(1.4\phi)$	=	15.67	Eq 10.39 Das (1990)
	$s_c = 1 + (B/L)(N_q/N_c)$ Strip	=	1.00	Table 10.2 Das (1990)
	$s_q = 1 + (B/L)\tan\phi$ Strip	=	1.00	
	$s_\gamma = 1 - 0.4\,(B/L)$ Strip	=	1.00	
For $D_f/B \leq 1$:	$d_c = d_q - (1-d_q)/(N_q \tan\phi)$	=	1.32	
	$d_q = 1 + 2\tan\phi\,(1 - \sin\phi)^2\, D_f/B$	=	1.29	
	$d_\gamma = 1$	=	1.00	
For $D_f/B > 1$:	$d_c = d_q - (1-d_q)/(N_q \tan\phi)$	=	1.25	
	$d_q = 1+2\tan\phi\,(1 - \sin\phi)^2\, \tan^{-1}(D_f/B)$	=	1.23	
	$d_\gamma = 1$	=	1.00	
For $\phi = 0$:	$d_c = 1 + 0.4\tan^{-1}(D_f/B)$	=	1.31	
	$d_\gamma = 1 + 0.4\,(D_f/B)$		1.02	
	$i_c = (1 - \beta/90)^2$	=	1.00	
	$i_q = i_c$	=	1.00	
	$i_\gamma = (1 - \beta/\phi)^2$	=	1.00	

			N_c term		N_q term		N_γ term
q_{ult} =	**10,095**	**psf =**	**0**	**+**	**7588**	**+**	**2507**

q_{all} = 3,360 psf = q_{ult} / FS

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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

▲ 5010.65

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO. 05996.01	DIVISION & GROUP G(B)	CALCULATION NO. 07 - 1	OPTIONAL TASK CODE	PAGE A2

ALLOWABLE BEARING CAPACITY STRIP FOOTING

Soil Properties:	ϕ =	30	Effective Stress Friction Angle (degrees)
	c =	0	Cohesion (psf)
	γ =	80	Unit weight of soil (pcf)
	γ_{surch} =	80	Unit weight of surcharge (pcf)
Foundation Properties:	B =	4	Footing Width (ft) L = 100.00 ft
	D_f =	4	Depth of Footing (ft) **Assume strip footing if L/B > 5**
	β =	10	Angle of load inclination from vertical (degrees)
	FS =	3	Factor of Safety

$q_{ult} = c\,N_c\,s_c\,d_c\,i_c + \gamma\,D_f\,N_q\,s_q\,d_q\,i_q + 1/2\,\gamma\,B\,N_\gamma\,s_\gamma\,d_\gamma\,i_\gamma$ **Meyerhoff General Bearing Capacity**

Equation			Value	Reference
$N_c = (N_q - 1)\cot(\phi)$		=	30.14	Eq 2-8 Bowles (1968)
$N_q = e^{\pi \tan\phi}\tan^2(45 + \phi/2)$		=	18.40	Eq 10.32 Das (1990)
$N_\gamma = (N_q - 1)\tan(1.4\phi)$		=	15.67	Eq 10.39 Das (1990)
$s_c = 1 + (B/L)(N_q/N_c)$	Strip	=	1.00	Table 10.2 Das (1990)
$s_q = 1 + (B/L)\tan\phi$	Strip	=	1.00	
$s_\gamma = 1 - 0.4\,(B/L)$	Strip	=	1.00	
For $D_f/B \le 1$: $d_c = d_q - (1-d_q)/(N_q \tan\phi)$		=	1.32	
$d_q = 1 + 2\tan\phi\,(1 - \sin\phi)^2\,D_f/B$		=	1.29	
$d_\gamma = 1$		=	1.00	
For $D_f/B > 1$: $d_c = d_q - (1-d_q)/(N_q \tan\phi)$		=	1.25	
$d_q = 1 + 2\tan\phi\,(1 - \sin\phi)^2\,\tan^{-1}(D_f/B)$		=	1.23	
$d_\gamma = 1$		=	1.00	
For $\phi = 0$: $d_c = 1 + 0.4\tan^{-1}(D_f/B)$		=	1.31	
$d_\gamma = 1 + 0.4\,(D_f/B)$			1.02	
$i_c = (1 - \beta/90)^2$		=	0.79	
$i_q = i_c$		=	0.79	
$i_\gamma = (1 - \beta/\phi)^2$		=	0.44	

			N_c term		N_q term		N_γ term
q_{ult} =	**7,110**	**psf =**	**0**	**+**	**5996**	**+**	**1114**

q_{all} = 2,360 psf = q_{ult} / FS

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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

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CALCULATION IDENTIFICATION NUMBER				PAGE A3
J.O. OR W.O. NO. 05996.01	DIVISION & GROUP G(B)	CALCULATION NO. 07-1	OPTIONAL TASK CODE	

ALLOWABLE BEARING CAPACITY STRIP FOOTING

Soil Properties:

ϕ =	30	Effective Stress Friction Angle (degrees)	
c =	0	Cohesion (psf)	
γ =	80	Unit weight of soil (pcf)	
γ_{surch} =	80	Unit weight of surcharge (pcf)	

Foundation Properties:

B =	4	Footing Width (ft)	L = 100.00 ft
D_f =	4	Depth of Footing (ft)	**Assume strip footing if L/B > 5**
β =	20	Angle of load inclination from vertical (degrees)	
FS =	3	Factor of Safety	

$$q_{ult} = c\,N_c\,s_c\,d_c\,i_c + \gamma\,D_f\,N_q\,s_q\,d_q\,i_q + 1/2\,\gamma\,B\,N_\gamma\,s_\gamma\,d_\gamma\,i_\gamma$$

Meyerhoff General Bearing Capacity

$N_c = (N_q - 1)\cot(\phi)$		=	30.14	Eq 2-8 Bowles (1968)
$N_q = e^{\pi \tan\phi}\tan^2(45 + \phi/2)$		=	18.40	Eq 10.32 Das (1990)
$N_\gamma = (N_q - 1)\tan(1.4\phi)$		=	15.67	Eq 10.39 Das (1990)
$s_c = 1 + (B/L)(N_q/N_c)$	Strip	=	1.00	Table 10.2 Das (1990)
$s_q = 1 + (B/L)\tan\phi$	Strip	=	1.00	
$s_\gamma = 1 - 0.4\,(B/L)$	Strip	=	1.00	
For $D_f/B \le 1$: $d_c = d_q - (1-d_q)/(N_q \tan\phi)$		=	1.32	
$d_q = 1 + 2\tan\phi\,(1-\sin\phi)^2\,D_f/B$		=	1.29	
$d_\gamma = 1$		=	1.00	
For $D_f/B > 1$: $d_c = d_q - (1-d_q)/(N_q \tan\phi)$		=	1.25	
$d_q = 1 + 2\tan\phi\,(1-\sin\phi)^2\,\tan^{-1}(D_f/B)$		=	1.23	
$d_\gamma = 1$		=	1.00	
For $\phi = 0$: $d_c = 1 + 0.4\tan^{-1}(D_f/B)$		=	1.31	
$d_\gamma = 1 + 0.4\,(D_f/B)$			1.02	
$i_c = (1 - \beta/90)^2$		=	0.60	
$i_q = i_c$		=	0.60	
$i_\gamma = (1 - \beta/\phi)^2$		=	0.11	

			N_c term		N_q term		N_γ term
q_{ult} =	4,869	psf =	0	+	4590	+	279

q_{all} = 1,620 psf = q_{ult} / FS

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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

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CALCULATION IDENTIFICATION NUMBER				PAGE A4
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	
05996.01	G(B)	07 - 1		

ALLOWABLE BEARING CAPACITY SQUARE FOOTING

Soil Properties:

$\phi =$ 30 Effective Stress Friction Angle (degrees)

$c =$ 0 Cohesion (psf)

$\gamma =$ 80 Unit weight of soil (pcf)

$\gamma_{surch} =$ 80 Unit weight of surcharge (pcf)

Foundation Properties:

$B =$ 4 Footing Width (ft) $L =$ 4.00 ft

$D_f =$ 4 Depth of Footing (ft)

$\beta =$ 0 Angle of load inclination from vertical (degrees)

$FS =$ 3 Factor of Safety

$q_{ult} = c\, N_c\, s_c\, d_c\, i_c + \gamma\, D_f\, N_q\, s_q\, d_q\, i_q + 1/2\, \gamma\, B\, N_\gamma\, s_\gamma\, d_\gamma\, i_\gamma$ **Meyerhoff General Bearing Capacity**

$N_c = (N_q - 1)\ \cot(\phi)$	=	30.14	Eq 2-8 Bowles (1968)
$N_q = e^{\pi \tan\phi}\ \tan^2(45 + \phi/2)$	=	18.40	Eq 10.32 Das (1990)
$N_\gamma = (N_q - 1)\ \tan(1.4\, \phi)$	=	15.67	Eq 10.39 Das (1990)
$s_c = 1 + (B/L)(N_q/N_c)$	=	1.61	Table 10.2 Das (1990)
$s_q = 1 + (B/L)\tan\phi$	=	1.58	
$s_\gamma = 1 - 0.4\,(B/L)$	=	0.60	
For $D_f/B \le 1$: $d_c = d_q - (1-d_q) / (N_q \tan\phi)$	=	1.32	
$d_q = 1 + 2\tan\phi\ (1 - \sin\phi)^2\, D_f/B$	=	1.29	
$d_\gamma = 1$	=	1.00	
For $D_f/B > 1$: $d_c = d_q - (1-d_q) / (N_q \tan\phi)$	=	1.25	
$d_q = 1 + 2\tan\phi\ (1 - \sin\phi)^2\ \tan^{-1}(D_f/B)$	=	1.23	
$d_\gamma = 1$	=	1.00	
For $\phi = 0$: $d_c = 1 + 0.4\tan^{-1}(D_f/B)$	=	1.31	
$d_\gamma = 1 + 0.4\,(D_f/B)$		1.40	
$i_c = (1 - \beta/90)^2$	=	1.00	
$i_q = i_c$	=	1.00	
$i_\gamma = (1 - \beta/\phi)^2$	=	1.00	

			N_c term		N_q term		N_γ term
q_{ult} =	13,473	psf =	0	+	11969	+	1504

q_{all} = 4,490 psf = q_{ult} / FS

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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

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CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO. 05996.01	DIVISION & GROUP G(B)	CALCULATION NO. 07 - 1	OPTIONAL TASK CODE	PAGE A5

ALLOWABLE BEARING CAPACITY SQUARE FOOTING

Soil Properties:

$\phi =$	30	Effective Stress Friction Angle (degrees)
$c =$	0	Cohesion (psf)
$\gamma =$	80	Unit weight of soil (pcf)
$\gamma_{surch} =$	80	Unit weight of surcharge (pcf)

Foundation Properties:

$B =$	4	Footing Width (ft) L = 4.00 ft
$D_f =$	4	Depth of Footing (ft)
$\beta =$	10	Angle of load inclination from vertical (degrees)
$FS =$	3	Factor of Safety

$q_{ult} = c\,N_c\,s_c\,d_c\,i_c + \gamma\,D_f\,N_q\,s_q\,d_q\,i_q + 1/2\,\gamma\,B\,N_\gamma\,s_\gamma\,d_\gamma\,i_\gamma$ **Meyerhoff General Bearing Capacity**

Equation		Value	Reference
$N_c = (N_q - 1)\cot(\phi)$	=	30.14	Eq 2-8 Bowles (1968)
$N_q = e^{\pi \tan\phi}\tan^2(45 + \phi/2)$	=	18.40	Eq 10.32 Das (1990)
$N_\gamma = (N_q - 1)\tan(1.4\,\phi)$	=	15.67	Eq 10.39 Das (1990)
$s_c = 1 + (B/L)(N_q/N_c)$	=	1.61	Table 10.2 Das (1990)
$s_q = 1 + (B/L)\tan\phi$	=	1.58	
$s_\gamma = 1 - 0.4\,(B/L)$	=	0.60	
For $D_f/B \leq 1$: $d_c = d_q - (1-d_q)/(N_q \tan\phi)$	=	1.32	
$d_q = 1 + 2\tan\phi\,(1 - \sin\phi)^2\,D_f/B$	=	1.29	
$d_\gamma = 1$	=	1.00	
For $D_f/B > 1$: $d_c = d_q - (1-d_q)/(N_q \tan\phi)$	=	1.25	
$d_q = 1+2\tan\phi\,(1 - \sin\phi)^2\,\tan^{-1}(D_f/B)$	=	1.23	
$d_\gamma = 1$	=	1.00	
For $\phi = 0$: $d_c = 1 + 0.4\tan^{-1}(D_f/B)$	=	1.31	
$d_\gamma = 1 + 0.4\,(D_f/B)$		1.40	
$i_c = (1 - \beta/90)^2$	=	0.79	
$i_q = i_c$	=	0.79	
$i_\gamma = (1 - \beta/\phi)^2$	=	0.44	

			N_c term		N_q term		N_γ term
$q_{ult} =$	10,126	psf =	0	+	9457	+	669

$q_{all} =$ **3,370** psf $= q_{ult} / FS$

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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

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CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE A6
05996.01	G(B)	07 - 1		

ALLOWABLE BEARING CAPACITY SQUARE FOOTING

Soil Properties:	ϕ =	30	Effective Stress Friction Angle (degrees)
	c =	0	Cohesion (psf)
	γ =	80	Unit weight of soil (pcf)
	γ_{surch} =	80	Unit weight of surcharge (pcf)
Foundation Properties:	B =	4	Footing Width (ft) L = 4.00 ft
	D_f =	4	Depth of Footing (ft)
	β =	20	Angle of load inclination from vertical (degrees)
	FS =	3	Factor of Safety

$q_{ult} = c\,N_c\,s_c\,d_c\,i_c + \gamma\,D_f\,N_q\,s_q\,d_q\,i_q + 1/2\,\gamma\,B\,N_\gamma\,s_\gamma\,d_\gamma\,i_\gamma$ **Meyerhoff General Bearing Capacity**

$N_c = (N_q - 1)\cot(\phi)$	=	30.14	Eq 2-8 Bowles (1968)
$N_q = e^{\pi \tan\phi}\tan^2(45 + \phi/2)$	=	18.40	Eq 10.32 Das (1990)
$N_\gamma = (N_q - 1)\tan(1.4\,\phi)$	=	15.67	Eq 10.39 Das (1990)
$s_c = 1 + (B/L)(N_q/N_c)$	=	1.61	Table 10.2 Das (1990)
$s_q = 1 + (B/L)\tan\phi$	=	1.58	
$s_\gamma = 1 - 0.4\,(B/L)$	=	0.60	
For $D_f/B \le 1$: $d_c = d_q - (1-d_q)/(N_q \tan\phi)$	=	1.32	
$d_q = 1 + 2\tan\phi\,(1-\sin\phi)^2\,D_f/B$	=	1.29	
$d_\gamma = 1$	=	1.00	
For $D_f/B > 1$: $d_c = d_q - (1-d_q)/(N_q \tan\phi)$	=	1.25	
$d_q = 1+2\tan\phi\,(1-\sin\phi)^2\,\tan^{-1}(D_f/B)$	=	1.23	
$d_\gamma = 1$	=	1.00	
For $\phi = 0$: $d_c = 1 + 0.4\tan^{-1}(D_f/B)$	=	1.31	
$d_\gamma = 1 + 0.4\,(D_f/B)$		1.40	
$i_c = (1 - \beta/90)^2$	=	0.60	
$i_q = i_c$	=	0.60	
$i_\gamma = (1 - \beta/\phi)^2$	=	0.11	

			N_c term		N_q term		N_γ term
q_{ult} =	7,408	psf =	0	+	7241	+	167

q_{all} = 2,460 psf = q_{ult} / FS

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APPENDIX B - DYNAMIC

ALLOWABLE BEARING CAPACITY STRIP FOOTING

Soil Properties:

ϕ =	0	Total Stress Friction Angle (degrees)
c =	2200	Cohesion (psf)
γ =	80	Unit weight of soil (pcf)
γ_{surch} =	80	Unit weight of surcharge (pcf)

Foundation Properties:

B =	4	Footing Width (ft)	L = 100.00 ft
D_f =	4	Depth of Footing (ft)	**Assume strip footing if L/B > 5**
β =	0	Angle of load inclination from vertical (degrees)	
FS =	1.1	Factor of Safety	

$q_{ult} = c\,N_c\,s_c\,d_c\,i_c + \gamma\,D_f\,N_q\,s_q\,d_q\,i_q + 1/2\,\gamma\,B\,N_\gamma\,s_\gamma\,d_\gamma\,i_\gamma$ **Meyerhoff General Bearing Capacity**

Equation			Value	Reference
$N_c = (N_q - 1)\cot(\phi)$		=	5.14	Eq 2-8 Bowles (1968)
$N_q = e^{\pi \tan\phi}\tan^2(45 + \phi/2)$		=	1.00	Eq 10.32 Das (1990)
$N_\gamma = (N_q - 1)\tan(1.4\phi)$		=	0.00	Eq 10.39 Das (1990)
$s_c = 1 + (B/L)(N_q/N_c)$	Strip	=	1.00	Table 10.2 Das (1990)
$s_q = 1 + (B/L)\tan\phi$	Strip	=	1.00	
$s_\gamma = 1 - 0.4\,(B/L)$	Strip	=	1.00	
For $D_f/B \le 1$: $d_c = d_q - (1-d_q)/(N_q \tan\phi)$		=	See below	
$d_q = 1 + 2\tan\phi\,(1 - \sin\phi)^2\,D_f/B$		=	1.00	
$d_\gamma = 1$		=	1.00	
For $D_f/B > 1$: $d_c = d_q - (1-d_q)/(N_q \tan\phi)$		=	See below	
$d_q = 1+2\tan\phi\,(1 - \sin\phi)^2\,\tan^{-1}(D_f/B)$		=	1.00	
$d_\gamma = 1$		=	1.00	
For $\phi = 0$: $d_c = 1 + 0.4\tan^{-1}(D_f/B)$		=	1.31	
$d_q = 1 + 0.4\,(D_f/B)$			1.02	
$i_c = (1 - \beta/90)^2$		=	1.00	
$i_q = i_c$		=	1.00	
$i_\gamma = (1 - \beta/\phi)^2$		=	1.00	

			N_c term		N_q term		N_γ term
q_{ult} =	15,181	psf =	14861	+	320	+	0

q_{all} = 13,800 psf = q_{ult} / FS

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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

▲ 5010.65

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO. 05996.01	DIVISION & GROUP G(B)	CALCULATION NO. 07 - 1	OPTIONAL TASK CODE	PAGE B2

ALLOWABLE BEARING CAPACITY STRIP FOOTING

Soil Properties:

$\phi =$ 0 Total Stress Friction Angle (degrees)

$c =$ 2200 Cohesion (psf)

$\gamma =$ 80 Unit weight of soil (pcf)

$\gamma_{surch} =$ 80 Unit weight of surcharge (pcf)

Foundation Properties:

$B =$ 4 Footing Width (ft) $L =$ 100.00 ft

$D_f =$ 4 Depth of Footing (ft) **Assume strip footing if L/B > 5**

$\beta =$ 10 Angle of load inclination from vertical (degrees)

$FS =$ 1.1 Factor of Safety

$q_{ult} = c\, N_c\, s_c\, d_c\, i_c + \gamma\, D_f\, N_q\, s_q\, d_q\, i_q + 1/2\, \gamma\, B\, N_\gamma\, s_\gamma\, d_\gamma\, i_\gamma$ **Meyerhoff General Bearing Capacity**

$N_c = (N_q - 1)\cot(\phi)$		=	5.14	Eq 2-8 Bowles (1968)
$N_q = e^{\pi \tan\phi}\tan^2(45 + \phi/2)$		=	1.00	Eq 10.32 Das (1990)
$N_\gamma = (N_q - 1)\tan(1.4\phi)$		=	0.00	Eq 10.39 Das (1990)
$s_c = 1 + (B/L)(N_q/N_c)$	Strip	=	1.00	Table 10.2 Das (1990)
$s_q = 1 + (B/L)\tan\phi$	Strip	=	1.00	
$s_\gamma = 1 - 0.4(B/L)$	Strip	=	1.00	
For $D_f/B \le 1$: $d_c = d_q - (1-d_q)/(N_q \tan\phi)$		=	See below	
$d_q = 1 + 2\tan\phi\,(1-\sin\phi)^2 D_f/B$		=	1.00	
$d_\gamma = 1$		=	1.00	
For $D_f/B > 1$: $d_c = d_q - (1-d_q)/(N_q \tan\phi)$		=	See below	
$d_q = 1 + 2\tan\phi\,(1-\sin\phi)^2 \tan^{-1}(D_f/B)$		=	1.00	
$d_\gamma = 1$		=	1.00	
For $\phi = 0$: $d_c = 1 + 0.4\tan^{-1}(D_f/B)$		=	1.31	
$d_\gamma = 1 + 0.4(D_f/B)$			1.02	
$i_c = (1 - \beta/90)^2$		=	0.79	
$i_q = i_c$		=	0.79	
$i_\gamma = (1 - \beta/\phi)^2$		=	1.00	

			N_c term		N_q term		N_γ term
$q_{ult} =$	11,994	psf =	11742	+	253	+	0

$q_{all} =$ 10,900 psf $= q_{ult} / FS$

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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

▲ 5010.65

CALCULATION IDENTIFICATION NUMBER				PAGE 83
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	
05996.01	G(B)	07 - 1		

ALLOWABLE BEARING CAPACITY STRIP FOOTING

Soil Properties:	ϕ =	0	Total Stress Friction Angle (degrees)	
	c =	2200	Cohesion (psf)	
	γ =	80	Unit weight of soil (pcf)	
	γ_{surch} =	80	Unit weight of surcharge (pcf)	
Foundation Properties:	B =	4	Footing Width (ft)	L = 100.00 ft
	D_f =	4	Depth of Footing (ft)	**Assume strip footing if L/B > 5**
	β =	20	Angle of load inclination from vertical (degrees)	
	FS =	1.1	Factor of Safety	

$q_{ult} = c\,N_c\,s_c\,d_c\,i_c + \gamma\,D_f\,N_q\,s_q\,d_q\,i_q + 1/2\,\gamma\,B\,N_\gamma\,s_\gamma\,d_\gamma\,i_\gamma$ **Meyerhoff General Bearing Capacity**

$N_c = (N_q - 1)\cot(\phi)$		=	5.14	Eq 2-8 Bowles (1968)
$N_q = e^{\pi \tan\phi}\tan^2(45 + \phi/2)$		=	1.00	Eq 10.32 Das (1990)
$N_\gamma = (N_q - 1)\tan(1.4\phi)$		=	0.00	Eq 10.39 Das (1990)
$s_c = 1 + (B/L)(N_q/N_c)$	**Strip**	=	1.00	Table 10.2 Das (1990)
$s_q = 1 + (B/L)\tan\phi$	**Strip**	=	1.00	
$s_\gamma = 1 - 0.4\,(B/L)$	**Strip**	=	1.00	
For $D_f/B \le 1$: $d_c = d_q - (1-d_q)/(N_q \tan\phi)$		=	See below	
$d_q = 1 + 2\tan\phi\,(1 - \sin\phi)^2\,D_f/B$		=	1.00	
$d_\gamma = 1$		=	1.00	
For $D_f/B > 1$: $d_c = d_q - (1-d_q)/(N_q \tan\phi)$		=	See below	
$d_q = 1 + 2\tan\phi\,(1 - \sin\phi)^2\,\tan^{-1}(D_f/B)$		=	1.00	
$d_\gamma = 1$		=	1.00	
For $\phi = 0$: $d_c = 1 + 0.4\tan^{-1}(D_f/B)$		=	1.31	
$d_\gamma = 1 + 0.4\,(D_f/B)$			1.02	
$i_c = (1 - \beta/90)^2$		=	0.60	
$i_q = i_c$		=	0.60	
$i_\gamma = (1 - \beta/\phi)^2$		=	1.00	

			N_c term		N_q term		N_γ term
q_{ult} =	**9,183**	**psf =**	**8990**	+	**194**	+	**0**

q_{all} = 8,340 psf = q_{ult} / FS

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CALCULATION IDENTIFICATION NUMBER				PAGE B4
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	
05996.01	G(B)	07 - 1		

ALLOWABLE BEARING CAPACITY SQUARE FOOTING

Soil Properties:

$\phi =$	0	Total Stress Friction Angle (degrees)
$c =$	2200	Cohesion (psf)
$\gamma =$	80	Unit weight of soil (pcf)
$\gamma_{surch} =$	80	Unit weight of surcharge (pcf)

Foundation Properties:

$B =$	4	Footing Width (ft) $L =$ 4.00 ft
$D_f =$	4	Depth of Footing (ft)
$\beta =$	0	Angle of load inclination from vertical (degrees)
FS =	1.1	Factor of Safety

$q_{ult} = c\, N_c\, s_c\, d_c\, i_c + \gamma\, D_f\, N_q\, s_q\, d_q\, i_q + 1/2\, \gamma\, B\, N_\gamma\, s_\gamma\, d_\gamma\, i_\gamma$ **Meyerhoff General Bearing Capacity**

$N_c = (N_q - 1)\cot(\phi)$	=	5.14	Eq 2-8 Bowles (1968)
$N_q = e^{\pi \tan\phi}\tan^2(45 + \phi/2)$	=	1.00	Eq 10.32 Das (1990)
$N_\gamma = (N_q - 1)\tan(1.4\phi)$	=	0.00	Eq 10.39 Das (1990)
$s_c = 1 + (B/L)(N_q/N_c)$	=	1.19	Table 10.2 Das (1990)
$s_q = 1 + (B/L)\tan\phi$	=	1.00	
$s_\gamma = 1 - 0.4\,(B/L)$	=	0.60	
For $D_f/B \le 1$: $d_c = d_q - (1-d_q)/(N_q \tan\phi)$	=	See below	
$d_q = 1 + 2\tan\phi\,(1-\sin\phi)^2\, D_f/B$	=	1.00	
$d_\gamma = 1$	=	1.00	
For $D_f/B > 1$: $d_c = d_q - (1-d_q)/(N_q \tan\phi)$	=	See below	
$d_q = 1 + 2\tan\phi\,(1-\sin\phi)^2\tan^{-1}(D_f/B)$	=	1.00	
$d_\gamma = 1$	=	1.00	
For $\phi = 0$: $d_c = 1 + 0.4\tan^{-1}(D_f/B)$	=	1.31	
$d_\gamma = 1 + 0.4\,(D_f/B)$		1.40	
$i_c = (1 - \beta/90)^2$	=	1.00	
$i_q = i_c$	=	1.00	
$i_\gamma = (1 - \beta/\phi)^2$	=	1.00	

			N_c term		N_q term		N_γ term
$q_{ult} =$	18,072	psf =	17752	+	320	+	0

$q_{all} =$ 16,420 psf = q_{ult} / FS

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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

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CALCULATION IDENTIFICATION NUMBER				PAGE B5
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	
05996.01	G(B)	07 - 1		

ALLOWABLE BEARING CAPACITY SQUARE FOOTING

Soil Properties:

ϕ = 0 Total Stress Friction Angle (degrees)

c = 2200 Cohesion (psf)

γ = 80 Unit weight of soil (pcf)

γ_{surch} = 80 Unit weight of surcharge (pcf)

Foundation Properties:

B = 4 Footing Width (ft) L = 4.00 ft

D_f = 4 Depth of Footing (ft)

β = 10 Angle of load inclination from vertical (degrees)

FS = 1.1 Factor of Safety

$q_{ult} = c\,N_c\,s_c\,d_c\,i_c + \gamma\,D_f\,N_q\,s_q\,d_q\,i_q + 1/2\,\gamma\,B\,N_\gamma\,s_\gamma\,d_\gamma\,i_\gamma$ **Meyerhoff General Bearing Capacity**

$N_c = (N_q - 1)\cot(\phi)$	=	5.14	Eq 2-8 Bowles (1968)
$N_q = e^{\pi \tan\phi}\tan^2(45 + \phi/2)$	=	1.00	Eq 10.32 Das (1990)
$N_\gamma = (N_q - 1)\tan(1.4\phi)$	=	0.00	Eq 10.39 Das (1990)
$s_c = 1 + (B/L)(N_q/N_c)$	=	1.19	Table 10.2 Das (1990)
$s_q = 1 + (B/L)\tan\phi$	=	1.00	
$s_\gamma = 1 - 0.4\,(B/L)$	=	0.60	
For $D_f/B \le 1$: $d_c = d_q - (1-d_q)/(N_q \tan\phi)$	=	See below	
$d_q = 1 + 2\tan\phi\,(1 - \sin\phi)^2\,D_f/B$	=	1.00	
$d_\gamma = 1$	=	1.00	
For $D_f/B > 1$: $d_c = d_q - (1-d_q)/(N_q \tan\phi)$	=	See below	
$d_q = 1 + 2\tan\phi\,(1 - \sin\phi)^2\,\tan^{-1}(D_f/B)$	=	1.00	
$d_\gamma = 1$	=	1.00	
For $\phi = 0$: $d_c = 1 + 0.4\tan^{-1}(D_f/B)$	=	1.31	
$d_\gamma = 1 + 0.4\,(D_f/B)$		1.40	
$i_c = (1 - \beta/90)^2$	=	0.79	
$i_q = i_c$	=	0.79	
$i_\gamma = (1 - \beta/\phi)^2$	=	1.00	

			N_c term		N_q term		N_γ term
q_{ult} =	14,279	psf =	14026	+	253	+	0

q_{all} = 12,980 psf = q_{ult} / FS

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CALCULATION IDENTIFICATION NUMBER				PAGE B6
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	
05996.01	G(B)	07 - 1		

ALLOWABLE BEARING CAPACITY   SQUARE FOOTING

Soil Properties:	ϕ =	0	Total Stress Friction Angle (degrees)
	c =	2200	Cohesion (psf)
	γ =	80	Unit weight of soil (pcf)
	γ_{surch} =	80	Unit weight of surcharge (pcf)
Foundation Properties:	B =	4	Footing Width (ft) L = 4.00 ft
	D_f =	4	Depth of Footing (ft)
	β =	20	Angle of load inclination from vertical (degrees)
	FS =	1.1	Factor of Safety

$q_{ult} = c\,N_c\,s_c\,d_c\,i_c + \gamma\,D_f\,N_q\,s_q\,d_q\,i_q + 1/2\,\gamma\,B\,N_\gamma\,s_\gamma\,d_\gamma\,i_\gamma$ **Meyerhoff General Bearing Capacity**

$N_c = (N_q - 1)\cot(\phi)$	=	5.14	Eq 2-8 Bowles (1968)
$N_q = e^{\pi \tan\phi}\tan^2(45 + \phi/2)$	=	1.00	Eq 10.32 Das (1990)
$N_\gamma = (N_q - 1)\tan(1.4\phi)$	=	0.00	Eq 10.39 Das (1990)
$s_c = 1 + (B/L)(N_q/N_c)$	=	1.19	Table 10.2 Das (1990)
$s_q = 1 + (B/L)\tan\phi$	=	1.00	
$s_\gamma = 1 - 0.4\,(B/L)$	=	0.60	
For $D_f/B \le 1$: $d_c = d_q - (1-d_q)/(N_q \tan\phi)$	=	See below	
$d_q = 1 + 2\tan\phi\,(1 - \sin\phi)^2\,D_f/B$	=	1.00	
$d_\gamma = 1$	=	1.00	
For $D_f/B > 1$: $d_c = d_q - (1-d_q)/(N_q \tan\phi)$	=	See below	
$d_q = 1+2\tan\phi\,(1 - \sin\phi)^2\,\tan^{-1}(D_f/B)$	=	1.00	
$d_\gamma = 1$	=	1.00	
For $\phi = 0$: $d_c = 1 + 0.4\tan^{-1}(D_f/B)$	=	1.31	
$d_\gamma = 1 + 0.4\,(D_f/B)$		1.40	
$i_c = (1 - \beta/90)^2$	=	0.60	
$i_q = i_c$	=	0.60	
$i_\gamma = (1 - \beta/\phi)^2$	=	1.00	

			N_c term		N_q term		N_γ term
q_{ult} =	10,932	psf =	10739	+	194	+	0

q_{all} = 9,930 psf = q_{ult} / FS

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APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

$q =$ 1.85 ksf $\gamma_t =$ 80.00 pcf GWT > 100 ft below grade

$B =$ 7.00 ft $L =$ 70 ft (Strip Footing; L>>B)

$D_f =$ 2.50 ft $E_{max} =$ 3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1

ρ_{total} 2.01 "

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	3.50	4.25	0.34	1.75	2.00	20.00	0.240	0.96	1.58	1.92
1B	3.50	7.75	0.62	5.25	0.67	6.67	0.167	0.67	1.10	1.72
1C	7.50	13.25	1.06	10.75	0.33	3.26	0.097	0.39	0.64	1.70
1D	13.00	23.50	1.88	21.00	0.17	1.67	0.051	0.20	0.33	2.21

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, $b = B/2$ $n = l/z_{ftg}$, where $l = L/2$

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E/E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	3.50	1.58	0.093	0.45	1699	0.093	0.04
1B	3.50	1.10	0.050	0.59	2230	0.049	0.02
1C	7.50	0.64	0.022	0.75	2824	0.023	0.02
1D	13.00	0.33	0.010	0.86	3262	0.010	0.02
						Total =	0.10 inches

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times\ \varepsilon_{actual}$

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E/E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., $E = 2 \times (1+\mu)\ G$

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	3.50	0.34	1.92	0.44
1B	3.50	0.62	1.72	0.26
1C	7.50	1.06	1.70	0.26
1D	13.00	1.88	2.21	0.15
			Total =	1.12 inches

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times$ RR $\times \log(\sigma_{vf}/\sigma_{vo})$

Note: 6.00 ksf = Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

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APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

ρ_{total} 2.01 "

q =	1.85 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	7.00 ft	L =	70 ft (Strip Footing; L>>B)	
D_f =	2.50 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32 = Log_{10}(40 yrs x 525,960 min/yr)
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month inches	Log Cycles in 20 Yrs inches	Log Cycles in 40 Yrs inches
1A	3.50	1.92	0.32	0.032	0.06	0.09	0.10
1B	3.50	1.72	0.29	0.029	0.06	0.08	0.09
1C	7.50	1.70	0.28	0.029	0.12	0.19	0.19
1D	13.00	2.21	0.37	0.037	0.27	0.40	0.42
				Total =	0.51	0.77	0.80 inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	3.50	4.25	1.75	0.04	0.44	0.06	0.09	0.10
1B	3.50	7.75	5.25	0.02	0.26	0.06	0.08	0.09
1C	7.50	13.25	10.75	0.02	0.26	0.12	0.19	0.19
1D	13.00	23.50	21.00	0.02	0.15	0.27	0.40	0.42
			Total =	0.10	1.12	0.51	0.77	0.80 inches

Total = **1.21 inches of immediate settlement**
1.72 inches after 1 month
1.98 inches after 20 years
2.01 inches after 40 years

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STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE
05996.01	G(B)	07-1		C2

5010.65

5010.65

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE
05996.01	G(B)	07 - 1		C3

CALCULATION IDENTIFICATION NUMBER

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

					ρ_{total}
q =	1.70 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade	2.00 "
B =	8.00 ft	L =	80 ft (Strip Footing; L>>B)		
D_f =	2.50 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	4.00	4.50	0.36	2.00	2.00	20.00	0.240	0.96	1.44	1.80
1B	4.00	8.50	0.68	6.00	0.67	6.67	0.167	0.67	1.00	1.68
1C	7.50	14.25	1.14	11.75	0.34	3.40	0.101	0.40	0.60	1.74
1D	12.00	24.00	1.92	21.50	0.19	1.86	0.057	0.23	0.34	2.26

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, b=B/2 $n = l/z_{ftg}$, where l=L/2

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E/E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	4.00	1.44	0.077	0.49	1861	0.077	0.04
1B	4.00	1.00	0.040	0.64	2421	0.041	0.02
1C	7.50	0.60	0.020	0.76	2877	0.021	0.02
1D	12.00	0.34	0.010	0.86	3262	0.010	0.02
						Total =	0.09 inches

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., E = 2 x (1+μ) G

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	4.00	0.36	1.80	0.47
1B	4.00	0.68	1.68	0.26
1C	7.50	1.14	1.74	0.23
1D	12.00	1.92	2.26	0.14
			Total =	1.11 inches

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times RR \times \text{Log}(\sigma_{vf}/\sigma_{vo})$

Note: 6.00 ksf = Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

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APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

q = 1.70 ksf γ_t = 80.00 pcf GWT > 100 ft below grade ρ_{total} 2.00 "

B = 8.00 ft L = 80 ft (Strip Footing; L>>B)

D_f = 2.50 ft E_{max} = 3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month inches	Log Cycles in 20 Yrs inches	Log Cycles in 40 Yrs inches
1A	4.00	1.80	0.30	0.030	0.07	0.10	0.11
1B	4.00	1.68	0.28	0.029	0.06	0.10	0.10
1C	7.50	1.74	0.29	0.030	0.12	0.19	0.19
1D	12.00	2.26	0.38	0.038	0.25	0.38	0.40
				Total =	0.51	0.77	0.80 inches

= Log_{10}(40 yrs x 525,960 min/yr)

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	4.00	4.50	2.00	0.04	0.47	0.07	0.10	0.11
1B	4.00	8.50	6.00	0.02	0.26	0.06	0.10	0.10
1C	7.50	14.25	11.75	0.02	0.23	0.12	0.19	0.19
1D	12.00	24.00	21.50	0.02	0.14	0.25	0.38	0.40
			Total =	0.09	1.11	0.51	0.77	0.80 inches

Total = 1.20 inches of immediate settlement
1.71 inches after 1 month
1.97 inches after 20 years
2.00 inches after 40 years

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APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

q =	1.50 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade	ρ_{total} 1.98 "
B =	10.00 ft	L =	100 ft (Strip Footing; L>>B)		
D_f =	2.50 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	5.00	5.00	0.40	2.50	2.00	20.00	0.240	0.96	1.25	1.65
1B	5.00	10.00	0.80	7.50	0.67	6.67	0.167	0.67	0.87	1.67
1C	7.50	16.25	1.30	13.75	0.36	3.64	0.106	0.43	0.55	1.85
1D	10.00	25.00	2.00	22.50	0.22	2.22	0.068	0.27	0.35	2.35

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: m=b/z_{ftg}, b=B/2 n = l/z_{ftg}, where l=L/2

ELASTIC SETTLEMENTS:

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times\ \varepsilon_{actual}$

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	5.00	1.25	0.060	0.55	2074	0.060	0.04
1B	5.00	0.87	0.032	0.69	2613	0.033	0.02
1C	7.50	0.55	0.020	0.76	2877	0.019	0.02
1D	10.00	0.35	0.010	0.86	3262	0.011	0.01
						Total =	0.09 inches

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., $E = 2 \times (1+\mu)\ G$

PRIMARY CONSOLIDATION SETTLEMENTS:

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times$ RR $\times \text{Log}(\sigma_{vf}/\sigma_{vo})$

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	5.00	0.40	1.65	0.52
1B	5.00	0.80	1.67	0.27
1C	7.50	1.30	1.85	0.19
1D	10.00	2.00	2.35	0.12
			Total =	1.10 inches

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

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CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO. 05996.01

DIVISION & GROUP G(B)

CALCULATION NO. 07-1

OPTIONAL TASK CODE

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

q =	1.50 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade	ρ_{total} 1.98 "
B =	10.00 ft	L =	100 ft (Strip Footing; L>>B)		
D_f =	2.50 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

= Log_{10}(40 yrs x 525,960 min/yr)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month Inches	Log Cycles in 20 Yrs Inches	Log Cycles in 40 Yrs Inches
1A	5.00	1.65	0.27	0.029	0.08	0.12	0.13
1B	5.00	1.67	0.28	0.029	0.08	0.12	0.13
1C	7.50	1.85	0.31	0.031	0.13	0.20	0.20
1D	10.00	2.35	0.39	0.039	0.22	0.33	0.34
				Total =	0.51	0.77	0.80 inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	5.00	5.00	2.50	0.04	0.52	0.08	0.12	0.13
1B	5.00	10.00	7.50	0.02	0.27	0.08	0.12	0.13
1C	7.50	16.25	13.75	0.02	0.19	0.13	0.20	0.20
1D	10.00	25.00	22.50	0.01	0.12	0.22	0.33	0.34
			Total =	0.09	1.10	0.51	0.77	0.80 inches

Total =
1.18 inches of immediate settlement
1.69 inches after 1 month
1.95 inches after 20 years
1.98 inches after 40 years

STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET
5010.65
CALCULATION IDENTIFICATION NUMBER
J.O. OR W.O. NO. 05996.01
DIVISION & GROUP G(B)
CALCULATION NO. 07-1
OPTIONAL TASK CODE

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

ρ_{total} **2.01 "**

q =	2.90 ksf	γ_t =	80.00 pcf GWT > 100 ft below grade
B =	5.30 ft	L =	53 ft (Strip Footing; L>>B)
D_f =	4.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	2.65	5.33	0.43	1.33	2.00	20.00	0.240	0.96	2.48	2.90
1B	2.65	7.98	0.64	3.98	0.67	6.67	0.167	0.67	1.72	2.36
1C	5.30	11.95	0.96	7.95	0.33	3.33	0.099	0.39	1.02	1.97
1D	10.60	19.90	1.59	15.90	0.17	1.67	0.051	0.20	0.52	2.11

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, $b = B/2$ $n = l/z_{ftg}$, where $l = L/2$

ELASTIC SETTLEMENTS:

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times\ \varepsilon_{actual}$

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	2.65	2.48	0.340	0.19	728	0.340	0.11
1B	2.65	1.72	0.110	0.41	1564	0.110	0.04
1C	5.30	1.02	0.045	0.61	2321	0.044	0.03
1D	10.60	0.52	0.018	0.78	2936	0.018	0.02
						Total =	0.19 inches

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., $E = 2 \times (1+\mu)\ G$

PRIMARY CONSOLIDATION SETTLEMENTS:

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times$ RR $\times \text{Log}(\sigma_{vf}/\sigma_{vo})$

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	2.65	0.43	2.90	0.37
1B	2.65	0.64	2.36	0.25
1C	5.30	0.96	1.97	0.28
1D	10.60	1.59	2.11	0.22
			Total =	1.12 inches

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

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STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET

A 5010.65

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE
05996.01	G(B)	07-1		C7

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

$q =$ 2.90 ksf | $\gamma_t =$ 80.00 pcf | GWT > 100 ft below grade

$B =$ 5.30 ft | $L =$ 53 ft (Strip Footing; L>>B)

$D_f =$ 4.00 ft | $E_{max} =$ 3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1

ρ_{total} 2.01 "

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x $Log_{10}(\Delta t \text{ in min})$

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month inches	Log Cycles in 20 Yrs inches	Log Cycles in 40 Yrs inches
1A	2.65	2.90	0.48	0.053	0.08	0.12	0.12
1B	2.65	2.36	0.39	0.039	0.06	0.09	0.09
1C	5.30	1.97	0.33	0.033	0.10	0.15	0.16
1D	10.60	2.11	0.35	0.035	0.21	0.31	0.33
				Total =	0.44	0.67	0.70 inches

7.32 = Log_{10}(40 yrs x 525,960 min/yr)

Note: C_α = rate of secondary compression & is $f(\sigma_{vf}/\sigma_{mpp})$ - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	2.65	5.33	1.33	0.11	0.37	0.08	0.12	0.12
1B	2.65	7.98	3.98	0.04	0.25	0.06	0.09	0.09
1C	5.30	11.95	7.95	0.03	0.28	0.10	0.15	0.16
1D	10.60	19.90	15.90	0.02	0.22	0.21	0.31	0.33
			Total =	0.19	1.12	0.44	0.67	0.70 inches

Total =
1.32 inches of immediate settlement
1.76 inches after 1 month
1.99 inches after 20 years
2.01 inches after 40 years

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STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET
5010.65
CALCULATION IDENTIFICATION NUMBER
J.O. OR W.O. NO. 05996.01
DIVISION & GROUP G(B)
CALCULATION NO. 07-1
OPTIONAL TASK CODE

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

q = 2.50 ksf	γ_t = 80.00 pcf	GWT > 100 ft below grade		ρ_{total}
B = 6.00 ft	L = 60 ft (Strip Footing; L>>B)			1.99 "
D_f = 4.00 ft	E_{max} = 3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1			

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	3.00	5.50	0.44	1.50	2.00	20.00	0.240	0.96	2.09	2.53
1B	3.00	8.50	0.68	4.50	0.67	6.67	0.167	0.67	1.46	2.14
1C	6.00	13.00	1.04	9.00	0.33	3.33	0.099	0.39	0.86	1.90
1D	12.00	22.00	1.76	18.00	0.17	1.67	0.051	0.20	0.44	2.20

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, b=B/2 $n = l/z_{ftg}$, where l=L/2

ELASTIC SETTLEMENTS:

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times\ \varepsilon_{actual}$

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	3.00	2.09	0.170	0.33	1231	0.170	0.06
1B	3.00	1.46	0.080	0.48	1828	0.080	0.03
1C	6.00	0.86	0.030	0.70	2652	0.032	0.02
1D	12.00	0.44	0.015	0.80	3037	0.015	0.02
						Total =	0.13 inches

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., E = 2 x (1+μ) G

PRIMARY CONSOLIDATION SETTLEMENTS:

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times$ RR $\times \text{Log}(\sigma_{vf}/\sigma_{vo})$

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	3.00	0.44	2.53	0.38
1B	3.00	0.68	2.14	0.25
1C	6.00	1.04	1.90	0.26
1D	12.00	1.76	2.20	0.20
			Total =	1.09 inches

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO. 05996.01

DIVISION & GROUP G(B)

CALCULATION NO. 07-1

OPTIONAL TASK CODE

5010.65

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

q =	2.50 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	6.00 ft	L =	60 ft (Strip Footing; L>>B)	
D_f =	4.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

ρ_{total} 1.99 "

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month Inches	Log Cycles in 20 Yrs Inches	Log Cycles in 40 Yrs Inches
1A	3.00	2.53	0.42	0.043	0.07	0.11	0.11
1B	3.00	2.14	0.36	0.036	0.06	0.09	0.09
1C	6.00	1.90	0.32	0.032	0.11	0.16	0.17
1D	12.00	2.20	0.37	0.037	0.25	0.37	0.39
				Total =	0.48	0.73	0.76 inches

= Log_{10}(40 yrs x 525,960 min/yr)

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = $\frac{525,960 \text{ min/yr}}{12 \text{ months/yr}}$

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	3.00	5.50	1.50	0.06	0.38	0.07	0.11	0.11
1B	3.00	8.50	4.50	0.03	0.25	0.06	0.09	0.09
1C	6.00	13.00	9.00	0.02	0.26	0.11	0.16	0.17
1D	12.00	22.00	18.00	0.02	0.20	0.25	0.37	0.39
			Total =	0.13	1.09	0.48	0.73	0.76 inches

Total =
1.23 inches of immediate settlement
1.71 inches after 1 month
1.96 inches after 20 years
1.99 inches after 40 years

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

$q =$	2.20 ksf	$\gamma_t =$	80.00 pcf	GWT > 100 ft below grade	ρ_{total} 2.02 "
$B =$	7.00 ft	$L =$	70 ft (Strip Footing; L>>B)		
$D_f =$	4.00 ft	$E_{max} =$	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	3.50	5.75	0.46	1.75	2.00	20.00	0.240	0.96	1.80	2.26
1B	3.50	9.25	0.74	5.25	0.67	6.67	0.167	0.67	1.26	2.00
1C	7.00	14.50	1.16	10.50	0.33	3.33	0.099	0.39	0.74	1.90
1D	12.00	24.00	1.92	20.00	0.18	1.75	0.053	0.21	0.40	2.32

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

$I_{corner} = f(m \& n)$ based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, $b = B/2$ $n = l/z_{ftg}$, where $l = L/2$

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E/E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	3.50	1.80	0.120	0.40	1497	0.120	0.05
1B	3.50	1.26	0.060	0.55	2074	0.061	0.03
1C	7.00	0.74	0.030	0.70	2652	0.028	0.02
1D	12.00	0.40	0.010	0.86	3262	0.012	0.02
						Total =	0.12 inches

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., $E = 2 \times (1+\mu)\, G$

PRIMARY CONSOLIDATION SETTLEMENTS:

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times RR \times \text{Log}(\sigma_{vf}/\sigma_{vo})$

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	3.50	0.46	2.26	0.41
1B	3.50	0.74	2.00	0.25
1C	7.00	1.16	1.90	0.25
1D	12.00	1.92	2.32	0.17
			Total =	1.08 inches

Note: 6.00 ksf = Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

5010.65

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO. 05996.01

DIVISION & GROUP G(B)

CALCULATION NO. 07-1

OPTIONAL TASK CODE

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

ρ_{total} 2.02 "

q = 2.20 ksf
B = 7.00 ft
D_f = 4.00 ft

γ_t = 80.00 pcf
L = 70 ft (Strip Footing; L>>B)
E_{max} = 3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1

GWT > 100 ft below grade

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

= Log_{10}(40 yrs x 525,960 min/yr)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month Inches	Log Cycles in 20 Yrs Inches	Log Cycles in 40 Yrs Inches
1A	3.50	2.26	0.38	0.038	0.07	0.11	0.12
1B	3.50	2.00	0.33	0.033	0.06	0.10	0.10
1C	7.00	1.90	0.32	0.032	0.12	0.19	0.20
1D	12.00	2.32	0.39	0.039	0.26	0.40	0.41
				Total =	0.52	0.79	0.83 inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	Inches	Inches	Inches	Inches	Inches
1A	3.50	5.75	1.75	0.05	0.41	0.07	0.11	0.12
1B	3.50	9.25	5.25	0.03	0.25	0.06	0.10	0.10
1C	7.00	14.50	10.50	0.02	0.25	0.12	0.19	0.20
1D	12.00	24.00	20.00	0.02	0.17	0.26	0.40	0.41
			Total =	0.12	1.08	0.52	0.79	0.83 inches

Total =
1.20 inches of immediate settlement
1.72 inches after 1 month
1.99 inches after 20 years
2.02 inches after 40 years

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

J.O. OR W.O. NO. 05996.01 | DIVISION & GROUP G(B) | CALCULATION IDENTIFICATION NUMBER: CALCULATION NO. 07-1 | OPTIONAL TASK CODE | PAGE C13

5010.65

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

q =	2.00 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	8.00 ft	L =	80 ft (Strip Footing; L>>B)	
D_f =	4.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

ρ_{total} 1.98 "

STRESSES BENEATH FOOTING:

LAYER	ΔH (ft)	z_{grade} (ft)	σ_{vo} (ksf)	z_{ftg} (ft)	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$ (ksf)	σ_{vf} (ksf)
1A	4.00	6.00	0.48	2.00	2.00	20.00	0.240	0.96	1.61	2.09
1B	4.00	10.00	0.80	6.00	0.67	6.67	0.167	0.67	1.12	1.92
1C	8.00	16.00	1.28	12.00	0.33	3.33	0.099	0.39	0.66	1.94
1D	10.00	25.00	2.00	21.00	0.19	1.90	0.058	0.23	0.39	2.39

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, $b = B/2$ $n = l/z_{ftg}$, where $l = L/2$

ELASTIC SETTLEMENTS:

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

LAYER	ΔH (ft)	$\Delta\sigma_v$ (ksf)	$\varepsilon_{assumed}$ (%)	E / E_{max}	E (ksf)	ε_{actual} (%)	$\Delta\rho_{elastic}$ (inches)
1A	4.00	1.61	0.096	0.44	1672	0.096	0.05
1B	4.00	1.12	0.050	0.59	2230	0.050	0.02
1C	8.00	0.66	0.024	0.73	2776	0.024	0.02
1D	10.00	0.39	0.013	0.82	3116	0.013	0.02
						Total =	0.11 Inches

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., $E = 2 \times (1+\mu)\, G$

PRIMARY CONSOLIDATION SETTLEMENTS:

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times RR \times \log(\sigma_{vf}/\sigma_{vo})$

LAYER	ΔH (ft)	σ_{vo} (ksf)	σ_{vf} (ksf)	$\Delta\rho_{primary}$ (Inches)
1A	4.00	0.48	2.09	0.43
1B	4.00	0.80	1.92	0.26
1C	8.00	1.28	1.94	0.24
1D	10.00	2.00	2.39	0.13
			Total =	1.06 Inches

Note: 6.00 ksf = Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

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APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

ρ_{total} 1.98 "

q =	2.00 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	8.00 ft	L =	80 ft (Strip Footing; L>>B)	
D_f =	4.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32	= Log_{10}(40 yrs x 525,960 min/yr)
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month Inches	Log Cycles in 20 Yrs Inches	Log Cycles in 40 Yrs Inches	
1A	4.00	2.09	0.35	0.035	0.08	0.12	0.12	
1B	4.00	1.92	0.32	0.032	0.07	0.11	0.11	
1C	8.00	1.94	0.32	0.032	0.14	0.22	0.23	
1D	10.00	2.39	0.40	0.040	0.22	0.34	0.35	
				Total =	0.52	0.78	0.81	Inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = $\frac{525,960 \text{ min/yr}}{12 \text{ months/yr}}$

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{fig}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs	
	ft	ft	ft	inches	inches	inches	inches	inches	
1A	4.00	6.00	2.00	0.05	0.43	0.08	0.12	0.12	
1B	4.00	10.00	6.00	0.02	0.26	0.07	0.11	0.11	
1C	8.00	16.00	12.00	0.02	0.24	0.14	0.22	0.23	
1D	10.00	25.00	21.00	0.02	0.13	0.22	0.34	0.35	
			Total =	0.11	1.06	0.52	0.78	0.81	inches

Total =
1.17 inches of immediate settlement
1.68 inches after 1 month
1.95 inches after 20 years
1.98 inches after 40 years

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE
05996.01	G(B)	07-1		C15

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

$q =$ 1.80 ksf $\gamma_t =$ 80.00 pcf GWT > 100 ft below grade ρ_{total} 1.98 "

$B =$ 10.00 ft $L =$ 100 ft (Strip Footing; L>>B)

$D_f =$ 4.00 ft $E_{max} =$ 3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	5.00	6.50	0.52	2.50	2.00	20.00	0.240	0.96	1.42	1.94
1B	5.00	11.50	0.92	7.50	0.67	6.67	0.167	0.67	0.99	1.91
1C	7.00	17.50	1.40	13.50	0.37	3.70	0.108	0.43	0.64	2.04
1D	9.00	25.50	2.04	21.50	0.23	2.33	0.071	0.28	0.42	2.46

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, $b = B/2$ $n = l/z_{ftg}$, where $l = L/2$

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	5.00	1.42	0.075	0.50	1883	0.075	0.05
1B	5.00	0.99	0.042	0.63	2380	0.042	0.02
1C	7.00	0.64	0.025	0.73	2753	0.023	0.02
1D	9.00	0.42	0.015	0.80	3037	0.014	0.01
						Total =	0.10 inches

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., $E = 2 \times (1+\mu) G$

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	5.00	0.52	1.94	0.48
1B	5.00	0.92	1.91	0.27
1C	7.00	1.40	2.04	0.19
1D	9.00	2.04	2.46	0.12
			Total =	1.06 inches

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times RR \times \log(\sigma_{vf}/\sigma_{vo})$

Note: 6.00 ksf = Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

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APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

q = 1.80 ksf
B = 10.00 ft
D_f = 4.00 ft

γ_t = 80.00 pcf GWT > 100 ft below grade
L = 100 ft (Strip Footing; L>>B)
E_{max} = 3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1

ρ_{total} 1.98 "

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x $Log_{10}(\Delta t \text{ in min})$

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles In 1 month Inches	Log Cycles In 20 Yrs Inches	Log Cycles In 40 Yrs Inches
1A	5.00	1.94	0.32	0.032	0.09	0.14	0.14
1B	5.00	1.91	0.32	0.032	0.09	0.14	0.14
1C	7.00	2.04	0.34	0.034	0.13	0.20	0.21
1D	9.00	2.46	0.41	0.041	0.20	0.31	0.32
				Total =	0.52	0.78	0.82 inches

= Log_{10}(40 yrs x 525,960 min/yr)

Note: C_α = rate of secondary compression & is $f(\sigma_{vf}/\sigma_{mpp})$ - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0
525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr
43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	5.00	6.50	2.50	0.05	0.48	0.09	0.14	0.14
1B	5.00	11.50	7.50	0.02	0.27	0.09	0.14	0.14
1C	7.00	17.50	13.50	0.02	0.19	0.13	0.20	0.21
1D	9.00	25.50	21.50	0.01	0.12	0.20	0.31	0.32
			Total =	0.10	1.06	0.52	0.78	0.82 inches

Total =
1.17 inches of immediate settlement
1.68 inches after 1 month
1.95 inches after 20 years
1.98 inches after 40 years

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

ρ_{total} 2.03 "

q =	4.30 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	3.70 ft	L =	37 ft (Strip Footing; L>>B)	
D_f =	6.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	1.85	6.93	0.55	0.93	2.00	20.00	0.240	0.96	3.67	4.22
1B	1.85	8.78	0.70	2.78	0.67	6.67	0.167	0.67	2.55	3.25
1C	3.70	11.55	0.92	5.55	0.33	3.33	0.099	0.39	1.51	2.43
1D	7.40	17.10	1.37	11.10	0.17	1.67	0.051	0.20	0.77	2.14

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, $b = B/2$ $n = l/z_{ftg}$, where $l = L/2$

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E/E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	1.85	3.67	1.000	0.08	314	1.168	0.26
1B	1.85	2.55	0.364	0.19	702	0.364	0.08
1C	3.70	1.51	0.085	0.47	1776	0.085	0.04
1D	7.40	0.77	0.030	0.70	2652	0.029	0.03
						Total =	0.40 inches

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., $E = 2 \times (1+\mu)\, G$

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	1.85	0.55	4.22	0.27
1B	1.85	0.70	3.25	0.21
1C	3.70	0.92	2.43	0.26
1D	7.40	1.37	2.14	0.24
			Total =	0.98 inches

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times RR \times \log(\sigma_{vf}/\sigma_{vo})$

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

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APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

ρ_{total} 2.03 "

q =	4.30 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	3.70 ft	L =	37	ft (Strip Footing; L>>B)
D_f =	6.00 ft	E_{max} =	3780	ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x $Log_{10}(\Delta t \text{ in min})$

7.32 = Log_{10}(40 yrs x 525,960 min/yr)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32	
	ft	ksf		%/Log Cycle Time (min)	Log Cycles In 1 month inches	Log Cycles in 20 Yrs inches	Log Cycles in 40 Yrs inches	
1A	1.85	4.22	0.70	0.104	0.11	0.16	0.17	
1B	1.85	3.25	0.54	0.063	0.07	0.10	0.10	
1C	3.70	2.43	0.41	0.041	0.08	0.13	0.13	
1D	7.40	2.14	0.36	0.036	0.15	0.22	0.23	
				Total =	0.41	0.61	0.64	inches

Note: C_α = rate of secondary compression & is $f(\sigma_{vf}/\sigma_{mpp})$ - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = $\frac{525{,}960 \text{ min/yr}}{12 \text{ months/yr}}$

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs	
	ft	ft	ft	inches	inches	inches	inches	inches	
1A	1.85	6.93	0.93	0.26	0.27	0.11	0.16	0.17	
1B	1.85	8.78	2.78	0.08	0.21	0.07	0.10	0.10	
1C	3.70	11.55	5.55	0.04	0.26	0.08	0.13	0.13	
1D	7.40	17.10	11.10	0.03	0.24	0.15	0.22	0.23	
			Total =	0.40	0.98	0.41	0.61	0.64	inches

Total = **1.39 inches of immediate settlement**
1.79 inches after 1 month
2.00 inches after 20 years
2.03 inches after 40 years

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STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET
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CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE
05996.01	G(B)	07 - 1		C18

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

q =	3.30 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade	ρ_{total} 1.98 "
B =	5.00 ft	L =	50 ft (Strip Footing; L>>B)		
D_f =	6.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

STRESSES BENEATH FOOTING:

LAYER	ΔH ft	z_{grade} ft	σ_{vo} ksf	z_{ftg} ft	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$ ksf	σ_{vf} ksf
1A	2.50	7.25	0.58	1.25	2.00	20.00	0.240	0.96	2.71	3.29
1B	2.50	9.75	0.78	3.75	0.67	6.67	0.167	0.67	1.88	2.66
1C	5.00	13.50	1.08	7.50	0.33	3.33	0.099	0.39	1.11	2.19
1D	10.00	21.00	1.68	15.00	0.17	1.67	0.051	0.20	0.57	2.25

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, b=B/2 $n = l/z_{ftg}$, where l=L/2

ELASTIC SETTLEMENTS:

LAYER	ΔH ft	$\Delta\sigma_v$ ksf	$\varepsilon_{assumed}$ %	E/E_{max}	E ksf	ε_{actual} %	$\Delta\rho_{elastic}$ inches
1A	2.50	2.71	0.440	0.17	629	0.430	0.13
1B	2.50	1.88	0.135	0.37	1407	0.134	0.04
1C	5.00	1.11	0.055	0.57	2149	0.052	0.03
1D	10.00	0.57	0.022	0.75	2824	0.020	0.02
						Total =	0.22 inches

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E/E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., $E = 2 \times (1+\mu)\, G$

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH ft	σ_{vo} ksf	σ_{vf} ksf	$\Delta\rho_{primary}$ inches
1A	2.50	0.58	3.29	0.32
1B	2.50	0.78	2.66	0.22
1C	5.00	1.08	2.19	0.26
1D	10.00	1.68	2.25	0.21
			Total =	1.01 inches

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times$ RR $\times \text{Log}(\sigma_{vf}/\sigma_{vo})$

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE
05996.01	G(B)	07 - 1		C19

A 5010.65

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

ρ_{total} 1.98 "

q =	3.30 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade	
B =	5.00 ft	L =	50 ft (Strip Footing; L>>B)		
D_f =	6.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month Inches	Log Cycles in 20 Yrs Inches	Log Cycles in 40 Yrs Inches
1A	2.50	3.29	0.55	0.065	0.09	0.14	0.14
1B	2.50	2.66	0.44	0.047	0.06	0.10	0.10
1C	5.00	2.19	0.37	0.037	0.10	0.15	0.16
1D	10.00	2.25	0.38	0.038	0.21	0.32	0.34
				Total =	0.47	0.71	0.74 inches

= Log_{10}(40 yrs x 525,960 min/yr)

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = $\frac{525,960 \text{ min/yr}}{12 \text{ months/yr}}$

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	2.50	7.25	1.25	0.13	0.32	0.09	0.14	0.14
1B	2.50	9.75	3.75	0.04	0.22	0.06	0.10	0.10
1C	5.00	13.50	7.50	0.03	0.26	0.10	0.15	0.16
1D	10.00	21.00	15.00	0.02	0.21	0.21	0.32	0.34
			Total =	0.22	1.01	0.47	0.71	0.74 inches

Total =
1.24 inches of immediate settlement
1.71 inches after 1 month
1.95 inches after 20 years
1.98 inches after 40 years

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STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET

5010.65

CALCULATION IDENTIFICATION NUMBER
J.O. OR W.O. NO. 05996.01
DIVISION & GROUP G(B)
CALCULATION NO. 07-1
OPTIONAL TASK CODE

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

ρ_{total} 2.00 "

q = 2.80 ksf γ_t = 80.00 pcf GWT > 100 ft below grade

B = 6.00 ft L = 60 ft (Strip Footing; L>>B)

D_f = 6.00 ft E_{max} = 3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	3.00	7.50	0.60	1.50	2.00	20.00	0.240	0.96	2.23	2.83
1B	3.00	10.50	0.84	4.50	0.67	6.67	0.167	0.67	1.55	2.39
1C	6.00	15.00	1.20	9.00	0.33	3.33	0.099	0.39	0.92	2.12
1D	12.00	24.00	1.92	18.00	0.17	1.67	0.051	0.20	0.47	2.39

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: m=b/z_{ftg}, b=B/2 n = l/z_{ftg}, where l=L/2

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	3.00	2.23	0.210	0.28	1069	0.208	0.07
1B	3.00	1.55	0.085	0.47	1776	0.087	0.03
1C	6.00	0.92	0.035	0.67	2536	0.036	0.03
1D	12.00	0.47	0.016	0.79	3001	0.016	0.02
						Total =	0.15 inches

$\Delta\rho_{elastic}$ = ΔH x 12 in./ft x ε_{actual}

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., E = 2 x (1+μ) G

PRIMARY CONSOLIDATION SETTLEMENTS:

$\Delta\rho_{primary}$ = ΔH x 12 in./ft x RR x Log (σ_{vf}/σ_{vo})

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	3.00	0.60	2.83	0.34
1B	3.00	0.84	2.39	0.23
1C	6.00	1.20	2.12	0.25
1D	12.00	1.92	2.39	0.19
			Total =	1.01 inches

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

ρ_{total} 2.00 "

q = 2.80 ksf
B = 6.00 ft
D_f = 6.00 ft

γ_t = 80.00 pcf   GWT > 100 ft below grade
L = 60 ft (Strip Footing; L>>B)
E_{max} = 3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month Inches	Log Cycles in 20 Yrs Inches	Log Cycles in 40 Yrs Inches
1A	3.00	2.83	0.47	0.051	0.08	0.13	0.13
1B	3.00	2.39	0.40	0.040	0.07	0.10	0.10
1C	6.00	2.12	0.35	0.035	0.12	0.17	0.18
1D	12.00	2.39	0.40	0.040	0.27	0.40	0.42
				Total =	0.53	0.81	0.84 inches

7.32 = Log_{10}(40 yrs x 525,960 min/yr)

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0
525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr
43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	3.00	7.50	1.50	0.07	0.34	0.08	0.13	0.13
1B	3.00	10.50	4.50	0.03	0.23	0.07	0.10	0.10
1C	6.00	15.00	9.00	0.03	0.25	0.12	0.17	0.18
1D	12.00	24.00	18.00	0.02	0.19	0.27	0.40	0.42
			Total =	0.15	1.01	0.53	0.81	0.84 inches

Total = **1.16 inches of immediate settlement**
1.70 inches after 1 month
1.97 inches after 20 years
2.00 inches after 40 years

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

ρ_{total} = 1.99 "

q =	2.40 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	8.00 ft	L =	80 ft (Strip Footing; L>>B)	
D_f =	6.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	4.00	8.00	0.64	2.00	2.00	20.00	0.240	0.96	1.84	2.48
1B	4.00	12.00	0.96	6.00	0.67	6.67	0.167	0.67	1.28	2.24
1C	8.00	18.00	1.44	12.00	0.33	3.33	0.099	0.39	0.76	2.20
1D	8.00	26.00	2.08	20.00	0.20	2.00	0.061	0.24	0.47	2.55

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, b=B/2 $n = l/z_{ftg}$, where l=L/2

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	4.00	1.84	0.126	0.39	1460	0.126	0.06
1B	4.00	1.28	0.065	0.53	2006	0.064	0.03
1C	8.00	0.76	0.028	0.71	2690	0.028	0.03
1D	8.00	0.47	0.017	0.79	2968	0.016	0.02
						Total =	0.13 inches

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., E = 2 x (1+μ) G

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	4.00	0.64	2.48	0.40
1B	4.00	0.96	2.24	0.25
1C	8.00	1.44	2.20	0.25
1D	8.00	2.08	2.55	0.12
			Total =	1.01 inches

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times$ RR $\times \log(\sigma_{vf}/\sigma_{vo})$

Note: 6.00 ksf = Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

q =	2.40 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade	ρ_{total} 1.99 "
B =	8.00 ft	L =	80 ft (Strip Footing; L>>B)		
D_f =	6.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH ft	σ_{vf} ksf	σ_{vf}/σ_{mpp}	C_α %/Log Cycle Time (min)	4.64 Log Cycles in 1 month inches	7.02 Log Cycles in 20 Yrs inches	7.32 Log Cycles in 40 Yrs inches
1A	4.00	2.48	0.41	0.042	0.09	0.14	0.15
1B	4.00	2.24	0.37	0.037	0.08	0.13	0.13
1C	8.00	2.20	0.37	0.037	0.17	0.25	0.26
1D	8.00	2.55	0.42	0.044	0.19	0.29	0.31
				Total =	0.54	0.81	0.85 inches

= Log_{10}(40 yrs x 525,960 min/yr)

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH ft	z_{grade} ft	z_{ftg} ft	$\Delta\rho_{elastic}$ inches	$\Delta\rho_{primary}$ inches	Δ Secondary Settlement 1 month inches	20 yrs inches	40 yrs inches
1A	4.00	8.00	2.00	0.06	0.40	0.09	0.14	0.15
1B	4.00	12.00	6.00	0.03	0.25	0.08	0.13	0.13
1C	8.00	18.00	12.00	0.03	0.25	0.17	0.25	0.26
1D	8.00	26.00	20.00	0.02	0.12	0.19	0.29	0.31
			Total =	0.13	1.01	0.54	0.81	0.85 inches

Total = 1.14 inches of immediate settlement
1.68 inches after 1 month
1.96 inches after 20 years
1.99 inches after 40 years

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

q = 2.20 ksf — γ_t = 80.00 pcf — GWT > 100 ft below grade

B = 10.00 ft — L = 100 ft (Strip Footing; L>>B)

D_f = 6.00 ft — E_{max} = 3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1

ρ_{total} 2.00 "

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft				-	ksf	ksf
1A	5.00	8.50	0.68	2.50	2.00	20.00	0.240	0.96	1.65	2.33
1B	5.00	13.50	1.08	7.50	0.67	6.67	0.167	0.67	1.15	2.23
1C	5.00	18.50	1.48	12.50	0.40	4.00	0.115	0.46	0.79	2.27
1D	9.00	25.50	2.04	19.50	0.26	2.56	0.078	0.31	0.53	2.57

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ — $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ — $I_{center} = 4 \times I_{corner}$ — $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, $b = B/2$ — $n = l/z_{ftg}$, where $l = L/2$

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E/E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	5.00	1.65	0.100	0.43	1637	0.101	0.06
1B	5.00	1.15	0.052	0.58	2197	0.052	0.03
1C	5.00	0.79	0.032	0.69	2613	0.030	0.02
1D	9.00	0.53	0.020	0.76	2877	0.019	0.02
						Total =	0.13 inches

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., $E = 2 \times (1+\mu)\, G$

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	5.00	0.68	2.33	0.45
1B	5.00	1.08	2.23	0.26
1C	5.00	1.48	2.27	0.16
1D	9.00	2.04	2.57	0.15
			Total =	1.02 inches

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times RR \times \log(\sigma_{vf}/\sigma_{vo})$

Note: 6.00 ksf = Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

ρ_{total}

2.00 "

$q =$ 2.20 ksf
$B =$ 10.00 ft
$D_f =$ 6.00 ft

$\gamma_t =$ 80.00 pcf   GWT > 100 ft below grade
$L =$ 100 ft (Strip Footing; L>>B)
$E_{max} =$ 3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1

SECONDARY SETTLEMENTS:

Δ Secondary Settlement $= 12$ in./ft x C_α x $Log_{10}(\Delta t$ in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32	$= Log_{10}$(40 yrs x 525,960 min/yr)
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month inches	Log Cycles in 20 Yrs inches	Log Cycles in 40 Yrs inches	
1A	5.00	2.33	0.39	0.039	0.11	0.16	0.17	
1B	5.00	2.23	0.37	0.037	0.10	0.16	0.16	
1C	5.00	2.27	0.38	0.038	0.11	0.16	0.17	
1D	9.00	2.57	0.43	0.044	0.22	0.34	0.35	
				Total =	0.54	0.82	0.85	inches

Note: C_α = rate of secondary compression & is $f(\sigma_{vf}/\sigma_{mpp})$ - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs	
	ft	ft	ft	inches	inches	inches	inches	inches	
1A	5.00	8.50	2.50	0.06	0.45	0.11	0.16	0.17	
1B	5.00	13.50	7.50	0.03	0.26	0.10	0.16	0.16	
1C	5.00	18.50	12.50	0.02	0.16	0.11	0.16	0.17	
1D	9.00	25.50	19.50	0.02	0.15	0.22	0.34	0.35	
			Total =	0.13	1.02	0.54	0.82	0.85	inches

Total = 1.15 inches of immediate settlement
1.69 inches after 1 month
1.97 inches after 20 years
2.00 inches after 40 years

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STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET
CALCULATION IDENTIFICATION NUMBER
J.O. OR W.O. NO. 05996.01
DIVISION & GROUP G(B)
CALCULATION NO. 07 - 1
OPTIONAL TASK CODE

5010.65

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

ρ_{total} 2.03 "

q =	5.75 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	2.60 ft	L =	26 ft (Strip Footing; L>>B)	
D_f =	8.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

STRESSES BENEATH FOOTING:

LAYER	ΔH ft	z_{grade} ft	σ_{vo} ksf	z_{ftg} ft	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$ ksf	σ_{vf} ksf
1A	1.30	8.65	0.69	0.65	2.00	20.00	0.240	0.96	4.90	5.59
1B	1.30	9.95	0.80	1.95	0.67	6.67	0.167	0.67	3.41	4.21
1C	2.60	11.90	0.95	3.90	0.33	3.33	0.099	0.39	2.02	2.97
1D	5.20	15.80	1.26	7.80	0.17	1.67	0.051	0.20	1.03	2.30

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\quad \Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $\quad I_{center} = 4 \times I_{corner}$ $\quad \sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, b=B/2 $\quad n = l/z_{ftg}$, where l=L/2

ELASTIC SETTLEMENTS:

LAYER	ΔH ft	$\Delta\sigma_v$ ksf	$\varepsilon_{assumed}$ %	E/E_{max}	E ksf	ε_{actual} %	$\Delta\rho_{elastic}$ inches	
1A	1.30	4.90	1.000	0.08	314	1.563	0.24	E/E_{max} = 0.083 for ε > 1 %
1B	1.30	3.41	1.000	0.08	314	1.088	0.17	
1C	2.60	2.02	0.155	0.34	1301	0.155	0.05	
1D	5.20	1.03	0.046	0.61	2302	0.045	0.03	
						Total =	0.49	inches

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., $E = 2 \times (1+\mu)\ G$

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH ft	σ_{vo} ksf	σ_{vf} ksf	$\Delta\rho_{primary}$ inches
1A	1.30	0.69	5.59	0.20
1B	1.30	0.80	4.21	0.16
1C	2.60	0.95	2.97	0.22
1D	5.20	1.26	2.30	0.23
			Total =	0.80 inches

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times$ RR $\times \text{Log}(\sigma_{vf}/\sigma_{vo})$

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

ρ_{total} 2.03 "

q =	5.75 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	2.60 ft	L =	26 ft (Strip Footing; L>>B)	
D_f =	8.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32	= Log_{10}(40 yrs x 525,960 min/yr)
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month inches	Log Cycles in 20 Yrs inches	Log Cycles in 40 Yrs inches	
1A	1.30	5.59	0.93	0.283	0.20	0.31	0.32	
1B	1.30	4.21	0.70	0.103	0.07	0.11	0.12	
1C	2.60	2.97	0.49	0.054	0.08	0.12	0.12	
1D	5.20	2.30	0.38	0.038	0.11	0.17	0.17	
				Total =	0.47	0.71	0.74	inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs	
	ft	ft	ft	inches	inches	inches	inches	inches	
1A	1.30	8.65	0.65	0.24	0.20	0.20	0.31	0.32	
1B	1.30	9.95	1.95	0.17	0.16	0.07	0.11	0.12	
1C	2.60	11.90	3.90	0.05	0.22	0.08	0.12	0.12	
1D	5.20	15.80	7.80	0.03	0.23	0.11	0.17	0.17	
			Total =	0.49	0.80	0.47	0.71	0.74	inches

Total =
1.29 inches of immediate settlement
1.76 inches after 1 month
2.00 inches after 20 years
2.03 inches after 40 years

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STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET

5010.65

J.O. OR W.O. NO. 05996.01
CALCULATION IDENTIFICATION NUMBER
DIVISION & GROUP G(B)
CALCULATION NO. 07 - 1
OPTIONAL TASK CODE
PAGE C28

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

					ρ_{total}
q =	3.60 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade	2.00 "
B =	5.00 ft	L =	50 ft (Strip Footing; L>>B)		
D_f =	8.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	2.50	9.25	0.74	1.25	2.00	20.00	0.240	0.96	2.84	3.58
1B	2.50	11.75	0.94	3.75	0.67	6.67	0.167	0.67	1.98	2.92
1C	5.00	15.50	1.24	7.50	0.33	3.33	0.099	0.39	1.17	2.41
1D	10.00	23.00	1.84	15.00	0.17	1.67	0.051	0.20	0.60	2.44

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m=b/z_{ftg}$, b=B/2 $n = l/z_{ftg}$, where l=L/2

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E/E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	2.50	2.84	0.470	0.16	604	0.471	0.14
1B	2.50	1.98	0.145	0.36	1352	0.146	0.04
1C	5.00	1.17	0.055	0.57	2149	0.054	0.03
1D	10.00	0.60	0.020	0.76	2877	0.021	0.02
						Total =	0.24 inches

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., E = 2 x (1+μ) G

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	2.50	0.74	3.58	0.29
1B	2.50	0.94	2.92	0.21
1C	5.00	1.24	2.41	0.24
1D	10.00	1.84	2.44	0.21
			Total =	0.94 inches

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times RR \times \log(\sigma_{vf}/\sigma_{vo})$

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

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STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET

J.O. OR W.O. NO. 05996.01
DIVISION & GROUP G(B)
CALCULATION NO. 07 - 1
OPTIONAL TASK CODE
CALCULATION IDENTIFICATION NUMBER

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

q = 3.60 ksf	γ_t = 80.00 pcf	GWT > 100 ft below grade		ρ_{total} 2.00 "
B = 5.00 ft	L = 50 ft (Strip Footing; L>>B)			
D_f = 8.00 ft	E_{max} = 3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1			

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month inches	Log Cycles in 20 Yrs inches	Log Cycles in 40 Yrs inches
1A	2.50	3.58	0.60	0.074	0.10	0.16	0.16
1B	2.50	2.92	0.49	0.053	0.07	0.11	0.12
1C	5.00	2.41	0.40	0.040	0.11	0.17	0.18
1D	10.00	2.44	0.41	0.041	0.23	0.35	0.36
				Total =	0.52	0.78	0.82 inches

7.32 = Log_{10}(40 yrs x 525,960 min/yr)

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	2.50	9.25	1.25	0.14	0.29	0.10	0.16	0.16
1B	2.50	11.75	3.75	0.04	0.21	0.07	0.11	0.12
1C	5.00	15.50	7.50	0.03	0.24	0.11	0.17	0.18
1D	10.00	23.00	15.00	0.02	0.21	0.23	0.35	0.36
			Total =	0.24	0.94	0.52	0.78	0.82 inches

Total = **1.18 inches of immediate settlement**
1.70 inches after 1 month
1.97 inches after 20 years
2.00 inches after 40 years

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE
05996.01	G(B)	07 - 1		C31

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

$q =$	3.10 ksf	$\gamma_t =$	80.00 pcf	GWT > 100 ft below grade	ρ_{total} 1.97 "
$B =$	6.00 ft	$L =$	60 ft (Strip Footing; L>>B)		
$D_f =$	8.00 ft	$E_{max} =$	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	3.00	9.50	0.76	1.50	2.00	20.00	0.240	0.96	2.36	3.12
1B	3.00	12.50	1.00	4.50	0.67	6.67	0.167	0.67	1.64	2.64
1C	6.00	17.00	1.36	9.00	0.33	3.33	0.099	0.39	0.97	2.33
1D	10.00	25.00	2.00	17.00	0.18	1.76	0.054	0.21	0.53	2.53

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, $b = B/2$ $n = l/z_{ftg}$, where $l = L/2$

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	3.00	2.36	0.270	0.23	876	0.269	0.10
1B	3.00	1.64	0.100	0.43	1637	0.100	0.04
1C	6.00	0.97	0.040	0.64	2421	0.040	0.03
1D	10.00	0.53	0.018	0.78	2936	0.018	0.02
						Total =	0.18 inches

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., $E = 2 \times (1+\mu)\, G$

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	3.00	0.76	3.12	0.31
1B	3.00	1.00	2.64	0.21
1C	6.00	1.36	2.33	0.24
1D	10.00	2.00	2.53	0.17
			Total =	0.93 inches

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times$ RR $\times \text{Log}(\sigma_{vf}/\sigma_{vo})$

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

ρ_{total} 1.97 "

q =	3.10 ksf	γ_t =	80.00 pcf GWT > 100 ft below grade
B =	6.00 ft	L =	60 ft (Strip Footing; L>>B)
D_f =	8.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32	= Log_{10}(40 yrs x 525,960 min/yr)
	ft	ksf		%/Log Cycle Time (min)	Log Cycles In 1 month inches	Log Cycles In 20 Yrs inches	Log Cycles In 40 Yrs inches	
1A	3.00	3.12	0.52	0.059	0.10	0.15	0.16	
1B	3.00	2.64	0.44	0.046	0.08	0.12	0.12	
1C	6.00	2.33	0.39	0.039	0.13	0.20	0.20	
1D	10.00	2.53	0.42	0.043	0.24	0.36	0.38	
				Total =	0.55	0.83	0.86	inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs	
	ft	ft	ft	inches	inches	inches	inches	inches	
1A	3.00	9.50	1.50	0.10	0.31	0.10	0.15	0.16	
1B	3.00	12.50	4.50	0.04	0.21	0.08	0.12	0.12	
1C	6.00	17.00	9.00	0.03	0.24	0.13	0.20	0.20	
1D	10.00	25.00	17.00	0.02	0.17	0.24	0.36	0.38	
			Total =	0.18	0.93	0.55	0.83	0.86	inches

Total = **1.11 inches of immediate settlement**
1.66 inches after 1 month
1.94 inches after 20 years
1.97 inches after 40 years

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

ρ_{total} 1.97 "

q =	2.90 ksf	γ_t =	80.00 pcf GWT > 100 ft below grade
B =	7.00 ft	L =	70 ft (Strip Footing; L>>B)
D_f =	8.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	3.50	9.75	0.78	1.75	2.00	20.00	0.240	0.96	2.17	2.95
1B	3.50	13.25	1.06	5.25	0.67	6.67	0.167	0.67	1.51	2.57
1C	7.00	18.50	1.48	10.50	0.33	3.33	0.099	0.39	0.89	2.37
1D	8.00	26.00	2.08	18.00	0.19	1.94	0.059	0.24	0.54	2.62

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, b=B/2 $n = l/z_{ftg}$, where l=L/2

ELASTIC SETTLEMENTS:

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times\ \varepsilon_{actual}$

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	3.50	2.17	0.190	0.30	1145	0.189	0.08
1B	3.50	1.51	0.085	0.47	1776	0.085	0.04
1C	7.00	0.89	0.035	0.67	2536	0.035	0.03
1D	8.00	0.54	0.018	0.78	2936	0.018	0.02
						Total =	0.16 inches

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., E = 2 x (1+μ) G

PRIMARY CONSOLIDATION SETTLEMENTS:

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft x RR x Log $(\sigma_{vf}/\sigma_{vo})$

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	3.50	0.78	2.95	0.34
1B	3.50	1.06	2.57	0.23
1C	7.00	1.48	2.37	0.24
1D	8.00	2.08	2.62	0.13
			Total =	0.94 inches

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO. 05996.01

DIVISION & GROUP G(B)

CALCULATION NO. 07-1

OPTIONAL TASK CODE

PAGE C33

▲ 5010 65

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

ρ_{total} 1.97 "

q =	2.90 ksf	γ_t =	80.00 pcf GWT > 100 ft below grade
B =	7.00 ft	L =	70 ft (Strip Footing; L>>B)
D_f =	8.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32	= Log_{10}(40 yrs x 525,960 min/yr)
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month inches	Log Cycles in 20 Yrs inches	Log Cycles in 40 Yrs inches	
1A	3.50	2.95	0.49	0.054	0.10	0.16	0.17	
1B	3.50	2.57	0.43	0.044	0.09	0.13	0.14	
1C	7.00	2.37	0.40	0.040	0.16	0.24	0.25	
1D	8.00	2.62	0.44	0.045	0.20	0.31	0.32	
				Total =	0.55	0.83	0.87	inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs	
	ft	ft	ft	inches	inches	inches	inches	inches	
1A	3.50	9.75	1.75	0.08	0.34	0.10	0.16	0.17	
1B	3.50	13.25	5.25	0.04	0.23	0.09	0.13	0.14	
1C	7.00	18.50	10.50	0.03	0.24	0.16	0.24	0.25	
1D	8.00	26.00	18.00	0.02	0.13	0.20	0.31	0.32	
			Total =	0.16	0.94	0.55	0.83	0.87	inches

Total = **1.10 inches of immediate settlement**
1.65 inches after 1 month
1.94 inches after 20 years
1.97 inches after 40 years

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STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET
CALCULATION IDENTIFICATION NUMBER
J.O. OR W.O. NO. 05996.01
DIVISION & GROUP G(B)
CALCULATION NO. 07 - 1
OPTIONAL TASK CODE
PAGE C34

5010.65

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

q =	2.80 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade	ρ_{total} 2.01 "
B =	8.00 ft	L =	80 ft (Strip Footing; L>>B)		
D_f =	8.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	4.00	10.00	0.80	2.00	2.00	20.00	0.240	0.96	2.07	2.87
1B	4.00	14.00	1.12	6.00	0.67	6.67	0.167	0.67	1.44	2.56
1C	6.00	19.00	1.52	11.00	0.36	3.64	0.106	0.43	0.92	2.44
1D	8.00	26.00	2.08	18.00	0.22	2.22	0.068	0.27	0.59	2.67

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: m=b/z_{ftg}, b=B/2 n = l/z_{ftg}, where l=L/2

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E/E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	4.00	2.07	0.165	0.33	1253	0.165	0.08
1B	4.00	1.44	0.080	0.48	1828	0.079	0.04
1C	6.00	0.92	0.037	0.66	2488	0.037	0.03
1D	8.00	0.59	0.020	0.76	2877	0.020	0.02
						Total =	0.16 inches

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., E = 2 x (1+μ) G

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	4.00	0.80	2.87	0.37
1B	4.00	1.12	2.56	0.24
1C	6.00	1.52	2.44	0.21
1D	8.00	2.08	2.67	0.14
			Total =	0.97 inches

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times$ RR $\times \log(\sigma_{vf}/\sigma_{vo})$

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

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APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

q =	2.80 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	8.00 ft	L =	80 ft (Strip Footing; L>>B)	
D_f =	8.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

ρ_{total} 2.01 "

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month inches	Log Cycles in 20 Yrs inches	Log Cycles in 40 Yrs inches
1A	4.00	2.87	0.48	0.052	0.12	0.17	0.18
1B	4.00	2.56	0.43	0.044	0.10	0.15	0.15
1C	6.00	2.44	0.41	0.041	0.14	0.21	0.22
1D	8.00	2.67	0.44	0.047	0.21	0.31	0.33
				Total =	0.56	0.84	0.88 inches

= Log_{10}(40 yrs x 525,960 min/yr)

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	4.00	10.00	2.00	0.08	0.37	0.12	0.17	0.18
1B	4.00	14.00	6.00	0.04	0.24	0.10	0.15	0.15
1C	6.00	19.00	11.00	0.03	0.21	0.14	0.21	0.22
1D	8.00	26.00	18.00	0.02	0.14	0.21	0.31	0.33
			Total =	0.16	0.97	0.56	0.84	0.88 inches

Total =
1.13 inches of immediate settlement
1.69 inches after 1 month
1.97 inches after 20 years
2.01 inches after 40 years

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STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET
5010.65

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE
05996.01	G(B)	07-1		C36

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} 1.49 "

q =	2.70 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	5.10 ft	L =	5.10 ft (Square)	
D_f =	2.50 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	2.55	3.78	0.30	1.28	2.00	2.00	0.232	0.93	2.32	2.63
1B	2.55	6.33	0.51	3.83	0.67	0.67	0.121	0.48	1.21	1.72
1C	5.10	10.15	0.81	7.65	0.33	0.33	0.045	0.18	0.45	1.26
1D	10.20	17.80	1.42	15.30	0.17	0.17	0.013	0.05	0.13	1.55

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, b=B/2 $n = l/z_{ftg}$, where l=L/2

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	2.55	2.32	0.240	0.26	967	0.241	0.07
1B	2.55	1.21	0.057	0.56	2118	0.057	0.02
1C	5.10	0.45	0.015	0.80	3037	0.015	0.01
1D	10.20	0.13	0.004	0.93	3518	0.004	0.00
						Total =	0.10 inches

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., E = 2 x (1+μ) G

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	2.55	0.30	2.63	0.40
1B	2.55	0.51	1.72	0.23
1C	5.10	0.81	1.26	0.16
1D	10.20	1.42	1.55	0.06
			Total =	0.86 inches

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times$ RR $\times$ Log $(\sigma_{vf}/\sigma_{vo})$

Note: 6.00 ksf = Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} 1.49 "

q =	2.70 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	5.10 ft	L =	5.10 ft (Square)	
D_f =	2.50 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32	= Log_{10}(40 yrs x 525,960 min/yr)
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month inches	Log Cycles in 20 Yrs inches	Log Cycles in 40 Yrs inches	
1A	2.55	2.63	0.44	0.046	0.06	0.10	0.10	
1B	2.55	1.72	0.29	0.029	0.04	0.06	0.07	
1C	5.10	1.26	0.21	0.025	0.07	0.11	0.11	
1D	10.20	1.55	0.26	0.026	0.16	0.24	0.25	
				Total =	0.34	0.51	0.53	inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs	
	ft	ft	ft	inches	inches	inches	inches	inches	
1A	2.55	3.78	1.28	0.07	0.40	0.06	0.10	0.10	
1B	2.55	6.33	3.83	0.02	0.23	0.04	0.06	0.07	
1C	5.10	10.15	7.65	0.01	0.16	0.07	0.11	0.11	
1D	10.20	17.80	15.30	0.00	0.06	0.16	0.24	0.25	
			Total =	0.10	0.86	0.34	0.51	0.53	inches

Total = **0.96 inches of immediate settlement**
1.30 inches after 1 month
1.47 inches after 20 years
1.49 inches after 40 years

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} 1.52 "

q =	2.20 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	6.00 ft	L =	6.00 ft (Square)	
D_f =	2.50 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	3.00	4.00	0.32	1.50	2.00	2.00	0.232	0.93	1.86	2.18
1B	3.00	7.00	0.56	4.50	0.67	0.67	0.121	0.48	0.97	1.53
1C	6.00	11.50	0.92	9.00	0.33	0.33	0.045	0.18	0.36	1.28
1D	12.00	20.50	1.64	18.00	0.17	0.17	0.013	0.05	0.10	1.74

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m=b/z_{ftg}$, $b=B/2$ $n = l/z_{ftg}$, where $l=L/2$

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E/E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	3.00	1.86	0.130	0.38	1436	0.130	0.05
1B	3.00	0.97	0.040	0.64	2421	0.040	0.01
1C	6.00	0.36	0.010	0.86	3262	0.011	0.01
1D	12.00	0.10	0.003	0.95	3590	0.003	0.00
						Total =	0.07 inches

$= \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., $E = 2 \times (1+\mu)\, G$

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	3.00	0.32	2.18	0.42
1B	3.00	0.56	1.53	0.22
1C	6.00	0.92	1.28	0.14
1D	12.00	1.64	1.74	0.05
			Total =	0.84 inches

$= \Delta H \times 12$ in./ft $\times RR \times Log(\sigma_{vf}/\sigma_{vo})$

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

q = 2.20 ksf	γ_t = 80.00 pcf	GWT > 100 ft below grade		ρ_{total}
B = 6.00 ft	L = 6.00 ft (Square)			1.52 "
D_f = 2.50 ft	E_{max} = 3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1			

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month inches	Log Cycles in 20 Yrs inches	Log Cycles in 40 Yrs inches
1A	3.00	2.18	0.36	0.036	0.06	0.09	0.10
1B	3.00	1.53	0.25	0.028	0.05	0.07	0.07
1C	6.00	1.28	0.21	0.026	0.09	0.13	0.14
1D	12.00	1.74	0.29	0.030	0.20	0.30	0.31
				Total =	0.39	0.59	0.62 inches

7.32 = Log_{10}(40 yrs x 525,960 min/yr)

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	3.00	4.00	1.50	0.05	0.42	0.06	0.09	0.10
1B	3.00	7.00	4.50	0.01	0.22	0.05	0.07	0.07
1C	6.00	11.50	9.00	0.01	0.14	0.09	0.13	0.14
1D	12.00	20.50	18.00	0.00	0.05	0.20	0.30	0.31
			Total =	0.07	0.84	0.39	0.59	0.62 inches

Total = **0.91 inches of immediate settlement**
1.30 inches after 1 month
1.50 inches after 20 years
1.52 inches after 40 years

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STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET

A 5010.65

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE
05996.01	G(B)	07-1		D4

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

q =	1.50 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade	ρ_{total} 1.53 "
B =	8.00 ft	L =	8.00 ft (Square)		
D_f =	2.50 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	4.00	4.50	0.36	2.00	2.00	2.00	0.232	0.93	1.21	1.57
1B	4.00	8.50	0.68	6.00	0.67	0.67	0.121	0.48	0.63	1.31
1C	8.00	14.50	1.16	12.00	0.33	0.33	0.045	0.18	0.23	1.39
1D	11.50	24.25	1.94	21.75	0.18	0.18	0.015	0.06	0.08	2.02

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, $b = B/2$ $n = l/z_{ftg}$, where $l = L/2$

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	Inches
1A	4.00	1.21	0.057	0.56	2118	0.057	0.03
1B	4.00	0.63	0.022	0.75	2824	0.022	0.01
1C	8.00	0.23	0.007	0.89	3362	0.007	0.01
1D	11.50	0.08	0.002	0.96	3641	0.002	0.00
						Total =	0.05 Inches

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., $E = 2 \times (1+\mu)\, G$

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	Inches
1A	4.00	0.36	1.57	0.43
1B	4.00	0.68	1.31	0.19
1C	8.00	1.16	1.39	0.11
1D	11.50	1.94	2.02	0.03
			Total =	0.76 Inches

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times$ RR $\times \log(\sigma_{vf}/\sigma_{vo})$

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE
05996.01	G(B)	07-1		D5

5010.65

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} 1.53 "

q =	1.50 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	8.00 ft	L =	8.00 ft (Square)	
D_f =	2.50 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

= Log_{10}(40 yrs x 525,960 min/yr)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month inches	Log Cycles in 20 Yrs inches	Log Cycles in 40 Yrs inches
1A	4.00	1.57	0.26	0.028	0.06	0.09	0.10
1B	4.00	1.31	0.22	0.026	0.06	0.09	0.09
1C	8.00	1.39	0.23	0.027	0.12	0.18	0.19
1D	11.50	2.02	0.34	0.034	0.22	0.33	0.34
				Total =	0.45	0.69	0.72 inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	4.00	4.50	2.00	0.03	0.43	0.06	0.09	0.10
1B	4.00	8.50	6.00	0.01	0.19	0.06	0.09	0.09
1C	8.00	14.50	12.00	0.01	0.11	0.12	0.18	0.19
1D	11.50	24.25	21.75	0.00	0.03	0.22	0.33	0.34
			Total =	0.05	0.76	0.45	0.69	0.72 inches

Total = **0.81 inches of immediate settlement**
1.26 inches after 1 month
1.50 inches after 20 years
1.53 inches after 40 years

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

q =	1.20 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade	ρ_{total}
B =	10.00 ft	L =	10.00 ft (Square)		1.48 "
D_f =	2.50 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	5.00	5.00	0.40	2.50	2.00	2.00	0.232	0.93	0.93	1.33
1B	5.00	10.00	0.80	7.50	0.67	0.67	0.121	0.48	0.48	1.28
1C	7.50	16.25	1.30	13.75	0.36	0.36	0.052	0.21	0.21	1.51
1D	10.00	25.00	2.00	22.50	0.22	0.22	0.022	0.09	0.09	2.09

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, b=B/2 $n = l/z_{ftg}$, where l=L/2

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E/E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	5.00	0.93	0.043	0.62	2360	0.039	0.02
1B	5.00	0.48	0.016	0.79	3001	0.016	0.01
1C	7.50	0.21	0.007	0.89	3362	0.006	0.01
1D	10.00	0.09	0.003	0.95	3590	0.002	0.00
						Total =	0.04 Inches

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., E = 2 x (1+μ) G

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	5.00	0.40	1.33	0.44
1B	5.00	0.80	1.28	0.17
1C	7.50	1.30	1.51	0.08
1D	10.00	2.00	2.09	0.03
			Total =	0.72 Inches

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times RR \times \text{Log}(\sigma_{vf}/\sigma_{vo})$

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} = 1.48 "

q = 1.20 ksf γ_t = 80.00 pcf GWT > 100 ft below grade

B = 10.00 ft L = 10.00 ft (Square)

D_f = 2.50 ft E_{max} = 3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

= Log_{10}(40 yrs x 525,960 min/yr)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month inches	Log Cycles in 20 Yrs inches	Log Cycles in 40 Yrs inches
1A	5.00	1.33	0.22	0.026	0.07	0.11	0.11
1B	5.00	1.28	0.21	0.026	0.07	0.11	0.11
1C	7.50	1.51	0.25	0.028	0.12	0.18	0.18
1D	10.00	2.09	0.35	0.035	0.19	0.29	0.31
				Total =	0.46	0.69	0.72 inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	5.00	5.00	2.50	0.02	0.44	0.07	0.11	0.11
1B	5.00	10.00	7.50	0.01	0.17	0.07	0.11	0.11
1C	7.50	16.25	13.75	0.01	0.08	0.12	0.18	0.18
1D	10.00	25.00	22.50	0.00	0.03	0.19	0.29	0.31
			Total =	0.04	0.72	0.46	0.69	0.72 inches

Total = **0.76 inches of immediate settlement**

1.22 inches after 1 month

1.45 inches after 20 years

1.48 inches after 40 years

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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

A 5010.65

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO. 05996.01

DIVISION & GROUP G(B)

CALCULATION NO. 07-1

OPTIONAL TASK CODE

PAGE D8

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} 1.51 "

q =	4.30 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	3.80 ft	L =	3.80 ft (Square)	
D_f =	4.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	1.90	4.95	0.40	0.95	2.00	2.00	0.232	0.93	3.70	4.10
1B	1.90	6.85	0.55	2.85	0.67	0.67	0.121	0.48	1.93	2.47
1C	3.80	9.70	0.78	5.70	0.33	0.33	0.045	0.18	0.71	1.49
1D	3.80	13.50	1.08	9.50	0.20	0.20	0.018	0.07	0.29	1.37

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: m=b/z_{ftg}, b=B/2 n = l/z_{ftg}, where l=L/2

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E/E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	1.90	3.70	1.000	0.08	314	1.180	0.27
1B	1.90	1.93	0.140	0.36	1379	0.140	0.03
1C	3.80	0.71	0.026	0.72	2732	0.026	0.01
1D	3.80	0.29	0.010	0.86	3262	0.009	0.00
						Total =	0.32 inches

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

E/E_{max} = 0.083 f

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E/E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., E = 2 x (1+μ) G

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	1.90	0.40	4.10	0.32
1B	1.90	0.55	2.47	0.21
1C	3.80	0.78	1.49	0.18
1D	3.80	1.08	1.37	0.06
			Total =	0.78 inches

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times RR \times \log(\sigma_{vf}/\sigma_{vo})$

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

q =	4.30 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade	ρ_{total} 1.51 "
B =	3.80 ft	L =	3.80 ft (Square)		
D_f =	4.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32	= Log_{10}(40 yrs x 525,960 min/yr)
	ft	ksf		%/Log Cycle Time (min)	Log Cycles In 1 month Inches	Log Cycles In 20 Yrs Inches	Log Cycles In 40 Yrs Inches	
1A	1.90	4.10	0.68	0.097	0.10	0.16	0.16	
1B	1.90	2.47	0.41	0.042	0.04	0.07	0.07	
1C	3.80	1.49	0.25	0.027	0.06	0.09	0.09	
1D	3.80	1.37	0.23	0.026	0.06	0.08	0.09	
				Total =	0.26	0.40	0.41	inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = $\frac{525,960 \text{ min/yr}}{12 \text{ months/yr}}$

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs	
	ft	ft	ft	inches	inches	inches	inches	inches	
1A	1.90	4.95	0.95	0.27	0.32	0.10	0.16	0.16	
1B	1.90	6.85	2.85	0.03	0.21	0.04	0.07	0.07	
1C	3.80	9.70	5.70	0.01	0.18	0.06	0.09	0.09	
1D	3.80	13.50	9.50	0.00	0.06	0.06	0.08	0.09	
			Total =	0.32	0.78	0.26	0.40	0.41	inches

Total = 1.10 inches of immediate settlement

1.36 inches after 1 month

1.49 inches after 20 years

1.51 inches after 40 years

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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

A 5010.65

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE
05996.01	G(B)	07-1	

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

$q =$	2.90 ksf	$\gamma_t =$	80.00 pcf	GWT > 100 ft below grade	ρ_{total} 1.51 "
$B =$	6.00 ft	$L =$	6.00 ft (Square)		
$D_f =$	4.00 ft	$E_{max} =$	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	3.00	5.50	0.44	1.50	2.00	2.00	0.232	0.93	2.40	2.84
1B	3.00	8.50	0.68	4.50	0.67	0.67	0.121	0.48	1.25	1.93
1C	6.00	13.00	1.04	9.00	0.33	0.33	0.045	0.18	0.46	1.50
1D	6.00	19.00	1.52	15.00	0.20	0.20	0.018	0.07	0.18	1.70

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m=b/z_{ftg}$, $b=B/2$ $n = l/z_{ftg}$, where $l=L/2$

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E/E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	Inches
1A	3.00	2.40	0.300	0.21	796	0.301	0.11
1B	3.00	1.25	0.060	0.55	2074	0.060	0.02
1C	6.00	0.46	0.015	0.80	3037	0.015	0.01
1D	6.00	0.18	0.005	0.91	3455	0.005	0.00
						Total =	0.15 Inches

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times\ \varepsilon_{actual}$

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., $E = 2 \times (1+\mu)\ G$

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	3.00	0.44	2.84	0.41
1B	3.00	0.68	1.93	0.23
1C	6.00	1.04	1.50	0.16
1D	6.00	1.52	1.70	0.05
			Total =	0.85 Inches

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times$ RR $\times$ Log $(\sigma_{vf}/\sigma_{vo})$

Note: 6.00 ksf = Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

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STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET

A 5010.65

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE
05996.01	G(B)	07-1		D11

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} 1.51 "

q =	2.90 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	6.00 ft	L =	6.00 ft (Square)	
D_f =	4.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month inches	Log Cycles in 20 Yrs inches	Log Cycles in 40 Yrs inches
1A	3.00	2.84	0.47	0.051	0.09	0.13	0.13
1B	3.00	1.93	0.32	0.032	0.05	0.08	0.08
1C	6.00	1.50	0.25	0.028	0.09	0.14	0.15
1D	6.00	1.70	0.28	0.029	0.10	0.15	0.15
				Total =	0.33	0.50	0.52 inches

= Log_{10}(40 yrs x 525,960 min/yr)

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	3.00	5.50	1.50	0.11	0.41	0.09	0.13	0.13
1B	3.00	8.50	4.50	0.02	0.23	0.05	0.08	0.08
1C	6.00	13.00	9.00	0.01	0.16	0.09	0.14	0.15
1D	6.00	19.00	15.00	0.00	0.05	0.10	0.15	0.15
			Total =	0.15	0.85	0.33	0.50	0.52 inches

Total = 0.99 inches of immediate settlement
1.32 inches after 1 month
1.49 inches after 20 years
1.51 inches after 40 years

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

5010.65

CALCULATION IDENTIFICATION NUMBER			
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE
05996.01	G(B)	07-1	

PAGE D13

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} 1.51 "

q =	2.00 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	8.00 ft	L =	8.00 ft (Square)	
D_f =	4.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	4.00	6.00	0.48	2.00	2.00	2.00	0.232	0.93	1.56	2.04
1B	4.00	10.00	0.80	6.00	0.67	0.67	0.121	0.48	0.81	1.61
1C	8.00	16.00	1.28	12.00	0.33	0.33	0.045	0.18	0.30	1.58
1D	8.00	24.00	1.92	20.00	0.20	0.20	0.018	0.07	0.12	2.04

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, b=B/2 $n = l/z_{ftg}$, where l=L/2

ELASTIC SETTLEMENTS:

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	4.00	1.56	0.090	0.46	1727	0.090	0.04
1B	4.00	0.81	0.030	0.70	2652	0.031	0.01
1C	8.00	0.30	0.009	0.87	3292	0.009	0.01
1D	8.00	0.12	0.003	0.95	3590	0.003	0.00
						Total =	0.07 inches

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., $E = 2 \times (1+\mu)\, G$

PRIMARY CONSOLIDATION SETTLEMENTS:

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times RR \times \text{Log}(\sigma_{vf}/\sigma_{vo})$

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	4.00	0.48	2.04	0.42
1B	4.00	0.80	1.61	0.20
1C	8.00	1.28	1.58	0.12
1D	8.00	1.92	2.04	0.04
			Total =	0.79 inches

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

5010.65

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE
05996.01	G(B)	07-1		D14

CALCULATION IDENTIFICATION NUMBER

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} 1.51 "

q =	2.00 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	8.00 ft	L =	8.00 ft (Square)	
D_f =	4.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

SECONDARY SETTLEMENTS:

Δ Secondary Settlement $= 12 \text{ in./ft} \times C_\alpha \times \text{Log}_{10}(\Delta t \text{ in min})$

$= \text{Log}_{10}(40 \text{ yrs} \times 525{,}960 \text{ min/yr})$

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32	
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month Inches	Log Cycles in 20 Yrs Inches	Log Cycles in 40 Yrs Inches	
1A	4.00	2.04	0.34	0.034	0.08	0.11	0.12	
1B	4.00	1.61	0.27	0.028	0.06	0.09	0.10	
1C	8.00	1.58	0.26	0.028	0.12	0.19	0.19	
1D	8.00	2.04	0.34	0.034	0.15	0.23	0.24	
				Total =	0.41	0.62	0.65	inches

Note: C_α = rate of secondary compression & is $f(\sigma_{vf}/\sigma_{mpp})$ - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs	
	ft	ft	ft	inches	inches	inches	inches	inches	
1A	4.00	6.00	2.00	0.04	0.42	0.08	0.11	0.12	
1B	4.00	10.00	6.00	0.01	0.20	0.06	0.09	0.10	
1C	8.00	16.00	12.00	0.01	0.12	0.12	0.19	0.19	
1D	8.00	24.00	20.00	0.00	0.04	0.15	0.23	0.24	
			Total =	0.07	0.79	0.41	0.62	0.65	inches

Total = 0.86 inches of immediate settlement

1.27 inches after 1 month

1.48 inches after 20 years

1.51 inches after 40 years

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} **1.52 "**

q =	1.60 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	10.00 ft	L =	10.00 ft (Square)	
D_f =	4.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	5.00	6.50	0.52	2.50	2.00	2.00	0.232	0.93	1.19	1.71
1B	5.00	11.50	0.92	7.50	0.67	0.67	0.121	0.48	0.62	1.54
1C	7.00	17.50	1.40	13.50	0.37	0.37	0.053	0.21	0.27	1.67
1D	9.00	25.50	2.04	21.50	0.23	0.23	0.024	0.09	0.12	2.16

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, b=B/2 $n = l/z_{ftg}$, where l=L/2

ELASTIC SETTLEMENTS:

$\Delta\rho_{elastic} = \Delta H \times 12\ in./ft \times \varepsilon_{actual}$

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	5.00	1.19	0.050	0.59	2230	0.053	0.03
1B	5.00	0.62	0.020	0.76	2877	0.022	0.01
1C	7.00	0.27	0.009	0.87	3292	0.008	0.01
1D	9.00	0.12	0.003	0.95	3590	0.003	0.00
						Total =	0.06 inches

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., E = 2 x (1+μ) G

PRIMARY CONSOLIDATION SETTLEMENTS:

$\Delta\rho_{primary} = \Delta H \times 12\ in./ft \times RR \times Log(\sigma_{vf}/\sigma_{vo})$

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	5.00	0.52	1.71	0.43
1B	5.00	0.92	1.54	0.19
1C	7.00	1.40	1.67	0.09
1D	9.00	2.04	2.16	0.04
			Total =	0.75 inches

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

A 5010.65

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO. 05996.01

DIVISION & GROUP G(B)

CALCULATION NO. 07-1

OPTIONAL TASK CODE

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} 1.52 "

q =	1.60 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	10.00 ft	L =	10.00 ft (Square)	
D_f =	4.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32	= Log_{10}(40 yrs x 525,960 min/yr)
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month inches	Log Cycles in 20 Yrs inches	Log Cycles in 40 Yrs inches	
1A	5.00	1.71	0.29	0.029	0.08	0.12	0.13	
1B	5.00	1.54	0.26	0.028	0.08	0.12	0.12	
1C	7.00	1.67	0.28	0.029	0.11	0.17	0.18	
1D	9.00	2.16	0.36	0.036	0.18	0.27	0.28	
				Total =	0.45	0.68	0.71	inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs	
	ft	ft	ft	inches	inches	inches	inches	inches	
1A	5.00	6.50	2.50	0.03	0.43	0.08	0.12	0.13	
1B	5.00	11.50	7.50	0.01	0.19	0.08	0.12	0.12	
1C	7.00	17.50	13.50	0.01	0.09	0.11	0.17	0.18	
1D	9.00	25.50	21.50	0.00	0.04	0.18	0.27	0.28	
			Total =	0.06	0.75	0.45	0.68	0.71	inches

Total = **0.81 inches of immediate settlement**
1.26 inches after 1 month
1.49 inches after 20 years
1.52 inches after 40 years

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

q =	6.50 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade	ρ_{total} 1.50 "
B =	2.20 ft	L =	2.20 ft (Square)		
D_f =	6.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	1.10	6.55	0.52	0.55	2.00	2.00	0.232	0.93	5.60	6.12
1B	1.10	7.65	0.61	1.65	0.67	0.67	0.121	0.48	2.91	3.53
1C	4.00	10.20	0.82	4.20	0.26	0.26	0.029	0.12	0.71	1.52
1D	4.00	14.20	1.14	8.20	0.13	0.13	0.008	0.03	0.20	1.34

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, $b = B/2$ $n = l/z_{ftg}$, where $l = L/2$

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$	$= \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$
	ft	ksf	%		ksf	%	inches	
1A	1.10	5.60	1.000	0.08	314	1.784	0.24	E/E_{max} = 0.083 for ε > 1 %
1B	1.10	2.91	0.505	0.15	576	0.506	0.07	
1C	4.00	0.71	0.025	0.73	2753	0.026	0.01	
1D	4.00	0.20	0.006	0.90	3405	0.006	0.00	
						Total =	0.32	inches

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., $E = 2 \times (1+\mu)\, G$

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	1.10	0.52	6.12	0.20
1B	1.10	0.61	3.53	0.14
1C	4.00	0.82	1.52	0.18
1D	4.00	1.14	1.34	0.05
			Total =	0.57 inches

$= \Delta H \times 12$ in./ft $\times$ RR $\times \text{Log}(\sigma_{vf}/\sigma_{vo})$

Note: 6.00 ksf = Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} 1.50 "

q =	6.50 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	2.20 ft	L =	2.20 ft (Square)	
D_f =	6.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

= Log_{10}(40 yrs x 525,960 min/yr)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month Inches	Log Cycles in 20 Yrs Inches	Log Cycles in 40 Yrs Inches
1A	1.10	6.12	1.02	0.368	0.23	0.34	0.36
1B	1.10	3.53	0.59	0.073	0.04	0.07	0.07
1C	4.00	1.52	0.25	0.028	0.06	0.09	0.10
1D	4.00	1.34	0.22	0.026	0.06	0.09	0.09
				Total =	0.39	0.59	0.62 Inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	1.10	6.55	0.55	0.24	0.20	0.23	0.34	0.36
1B	1.10	7.65	1.65	0.07	0.14	0.04	0.07	0.07
1C	4.00	10.20	4.20	0.01	0.18	0.06	0.09	0.10
1D	4.00	14.20	8.20	0.00	0.05	0.06	0.09	0.09
			Total =	0.32	0.57	0.39	0.59	0.62 inches

Total = **0.89 inches of immediate settlement**

1.27 inches after 1 month

1.47 inches after 20 years

1.50 inches after 40 years

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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO. 05996.01

DIVISION & GROUP G(B)

CALCULATION NO. 07-1

OPTIONAL TASK CODE

A 5010.65

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

q =	5.40 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade	ρ_{total}
B =	3.00 ft	L =	3.00 ft (Square)		1.52 "
D_f =	6.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	1.50	6.75	0.54	0.75	2.00	2.00	0.232	0.93	4.57	5.11
1B	1.50	8.25	0.66	2.25	0.67	0.67	0.121	0.48	2.38	3.04
1C	4.00	11.00	0.88	5.00	0.30	0.30	0.037	0.15	0.74	1.62
1D	4.00	15.00	1.20	9.00	0.17	0.17	0.013	0.05	0.25	1.45

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m=b/z_{ftg}$, b=B/2 $n = l/z_{ftg}$, where l=L/2

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E/E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$	$= \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$
	ft	ksf	%		ksf	%	Inches	
1A	1.50	4.57	1.000	0.08	314	1.458	0.26	E/E_{max} = 0.083 for ε > 1 %
1B	1.50	2.38	0.280	0.22	849	0.281	0.05	
1C	4.00	0.74	0.030	0.70	2652	0.028	0.01	
1D	4.00	0.25	0.008	0.88	3324	0.008	0.00	
						Total =	0.33	Inches

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., E = 2 x (1+μ) G

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	Inches
1A	1.50	0.54	5.11	0.25
1B	1.50	0.66	3.04	0.17
1C	4.00	0.88	1.62	0.18
1D	4.00	1.20	1.45	0.06
			Total =	0.65 Inches

$= \Delta H \times 12$ in./ft $\times$ RR $\times \log(\sigma_{vf}/\sigma_{vo})$

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} 1.52 "

q =	5.40 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	3.00 ft	L =	3.00 ft (Square)	
D_f =	6.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

= Log_{10}(40 yrs x 525,960 min/yr)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month inches	Log Cycles in 20 Yrs inches	Log Cycles in 40 Yrs inches
1A	1.50	5.11	0.85	0.206	0.17	0.26	0.27
1B	1.50	3.04	0.51	0.056	0.05	0.07	0.07
1C	4.00	1.62	0.27	0.028	0.06	0.10	0.10
1D	4.00	1.45	0.24	0.027	0.06	0.09	0.10
				Total =	0.34	0.52	0.54 inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	1.50	6.75	0.75	0.26	0.25	0.17	0.26	0.27
1B	1.50	8.25	2.25	0.05	0.17	0.05	0.07	0.07
1C	4.00	11.00	5.00	0.01	0.18	0.06	0.10	0.10
1D	4.00	15.00	9.00	0.00	0.06	0.06	0.09	0.10
			Total =	0.33	0.65	0.34	0.52	0.54 inches

Total = **0.98 inches of immediate settlement**
1.32 inches after 1 month
1.49 inches after 20 years
1.52 inches after 40 years

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

q =	4.50 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade	ρ_{total} 1.52 "
B =	4.00 ft	L =	4.00 ft (Square)		
D_f =	6.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	2.00	7.00	0.56	1.00	2.00	2.00	0.232	0.93	3.74	4.30
1B	2.00	9.00	0.72	3.00	0.67	0.67	0.121	0.48	1.95	2.67
1C	4.00	12.00	0.96	6.00	0.33	0.33	0.045	0.18	0.72	1.68
1D	4.00	16.00	1.28	10.00	0.20	0.20	0.018	0.07	0.29	1.57

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, b=B/2 $n = l/z_{ftg}$, where l=L/2

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E/E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$	= ΔH x 12 in./ft x ε_{actual}
	ft	ksf	%		ksf	%	inches	
1A	2.00	3.74	1.000	0.08	314	1.191	0.29	E/E_{max} = 0.083 for ε > 1 %
1B	2.00	1.95	0.140	0.36	1379	0.141	0.03	
1C	4.00	0.72	0.026	0.72	2732	0.026	0.01	
1D	4.00	0.29	0.010	0.86	3262	0.009	0.00	
						Total =	0.34	inches

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., E = 2 x (1+μ) G

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	2.00	0.56	4.30	0.30
1B	2.00	0.72	2.67	0.19
1C	4.00	0.96	1.68	0.16
1D	4.00	1.28	1.57	0.06
			Total =	0.71 inches

$\Delta\rho_{primary}$ = ΔH x 12 in./ft x RR x Log (σ_{vf}/σ_{vo})

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} 1.52 "

q = 4.50 ksf | γ_t = 80.00 pcf | GWT > 100 ft below grade
B = 4.00 ft | L = 4.00 ft (Square)
D_f = 6.00 ft | E_{max} = 3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32 = Log_{10}(40 yrs x 525,960 min/yr)
	ft	ksf		%/Log Cycle Time (min)	Log Cycles In 1 month Inches	Log Cycles In 20 Yrs Inches	Log Cycles In 40 Yrs Inches
1A	2.00	4.30	0.72	0.111	0.12	0.19	0.19
1B	2.00	2.67	0.44	0.047	0.05	0.08	0.08
1C	4.00	1.68	0.28	0.029	0.06	0.10	0.10
1D	4.00	1.57	0.26	0.028	0.06	0.10	0.10
				Total =	0.30	0.46	0.48 inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0
525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr
43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	2.00	7.00	1.00	0.29	0.30	0.12	0.19	0.19
1B	2.00	9.00	3.00	0.03	0.19	0.05	0.08	0.08
1C	4.00	12.00	6.00	0.01	0.16	0.06	0.10	0.10
1D	4.00	16.00	10.00	0.00	0.06	0.06	0.10	0.10
			Total =	0.34	0.71	0.30	0.46	0.48 inches

Total =
1.05 inches of immediate settlement
1.35 inches after 1 month
1.50 inches after 20 years
1.52 inches after 40 years

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STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET
A 5010.65

CALCULATION IDENTIFICATION NUMBER
J.O. OR W.O. NO. 05996.01
DIVISION & GROUP G(B)
CALCULATION NO. 07-1
OPTIONAL TASK CODE
PAGE D22

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

					ρ_{total}
q =	3.40 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade	1.49 "
B =	6.00 ft	L =	6.00 ft (Square)		
D_f =	6.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	3.00	7.50	0.60	1.50	2.00	2.00	0.232	0.93	2.72	3.32
1B	3.00	10.50	0.84	4.50	0.67	0.67	0.121	0.48	1.41	2.25
1C	4.00	14.00	1.12	8.00	0.38	0.38	0.054	0.22	0.63	1.75
1D	5.00	18.50	1.48	12.50	0.24	0.24	0.025	0.10	0.29	1.77

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: m=b/z_{ftg}, b=B/2 n = l/z_{ftg}, where l=L/2

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$	= ΔH x 12 in./ft x ε_{actual}
	ft	ksf	%		ksf	%	inches	
1A	3.00	2.72	0.420	0.17	647	0.420	0.15	E/E_{max} = 0.083 for ε > 1 %
1B	3.00	1.41	0.075	0.50	1883	0.075	0.03	
1C	4.00	0.63	0.020	0.76	2877	0.022	0.01	
1D	5.00	0.29	0.010	0.86	3262	0.009	0.01	
						Total =	0.19	inches

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., E = 2 x (1+μ) G

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	3.00	0.60	3.32	0.37
1B	3.00	0.84	2.25	0.22
1C	4.00	1.12	1.75	0.13
1D	5.00	1.48	1.77	0.07
			Total =	0.79 inches

$\Delta\rho_{primary}$ = ΔH x 12 in./ft x RR x Log (σ_{vf}/σ_{vo})

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

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APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} 1.49 "

q =	3.40 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	6.00 ft	L =	6.00 ft (Square)	
D_f =	6.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

= Log_{10}(40 yrs x 525,960 min/yr)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month Inches	Log Cycles in 20 Yrs Inches	Log Cycles in 40 Yrs Inches
1A	3.00	3.32	0.55	0.066	0.11	0.17	0.17
1B	3.00	2.25	0.38	0.038	0.06	0.09	0.10
1C	4.00	1.75	0.29	0.030	0.07	0.10	0.11
1D	5.00	1.77	0.30	0.030	0.08	0.13	0.13
				Total =	0.32	0.49	0.51 inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	3.00	7.50	1.50	0.15	0.37	0.11	0.17	0.17
1B	3.00	10.50	4.50	0.03	0.22	0.06	0.09	0.10
1C	4.00	14.00	8.00	0.01	0.13	0.07	0.10	0.11
1D	5.00	18.50	12.50	0.01	0.07	0.08	0.13	0.13
			Total =	0.19	0.79	0.32	0.49	0.51 inches

Total = **0.98 inches of immediate settlement**
1.30 inches after 1 month
1.47 inches after 20 years
1.49 inches after 40 years

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} = 1.51 "

q =	2.60 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	8.00 ft	L =	8.00 ft (Square)	
D_f =	6.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	4.00	8.00	0.64	2.00	2.00	2.00	0.232	0.93	1.97	2.61
1B	4.00	12.00	0.96	6.00	0.67	0.67	0.121	0.48	1.03	1.99
1C	6.00	17.00	1.36	11.00	0.36	0.36	0.052	0.21	0.44	1.80
1D	6.00	23.00	1.84	17.00	0.24	0.24	0.024	0.10	0.21	2.05

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, b=B/2 $n = l/z_{ftg}$, where l=L/2

ELASTIC SETTLEMENTS:

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times\ \varepsilon_{actual}$

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	4.00	1.97	0.150	0.35	1326	0.149	0.07
1B	4.00	1.03	0.045	0.61	2321	0.044	0.02
1C	6.00	0.44	0.014	0.81	3075	0.014	0.01
1D	6.00	0.21	0.005	0.91	3455	0.006	0.00
						Total =	0.11 inches

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., $E = 2 \times (1+\mu)\ G$

PRIMARY CONSOLIDATION SETTLEMENTS:

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times$ RR $\times \text{Log}(\sigma_{vf}/\sigma_{vo})$

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	4.00	0.64	2.61	0.41
1B	4.00	0.96	1.99	0.21
1C	6.00	1.36	1.80	0.12
1D	6.00	1.84	2.05	0.05
			Total =	0.79 inches

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

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APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

q =	2.60 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade	ρ_{total} 1.51 "
B =	8.00 ft	L =	8.00 ft (Square)		
D_f =	6.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

= Log_{10}(40 yrs x 525,960 min/yr)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles In 1 month Inches	Log Cycles In 20 Yrs Inches	Log Cycles In 40 Yrs Inches
1A	4.00	2.61	0.44	0.045	0.10	0.15	0.16
1B	4.00	1.99	0.33	0.033	0.07	0.11	0.12
1C	6.00	1.80	0.30	0.030	0.10	0.15	0.16
1D	6.00	2.05	0.34	0.034	0.11	0.17	0.18
				Total =	0.39	0.59	0.61 inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	4.00	8.00	2.00	0.07	0.41	0.10	0.15	0.16
1B	4.00	12.00	6.00	0.02	0.21	0.07	0.11	0.12
1C	6.00	17.00	11.00	0.01	0.12	0.10	0.15	0.16
1D	6.00	23.00	17.00	0.00	0.05	0.11	0.17	0.18
			Total =	0.11	0.79	0.39	0.59	0.61 inches

Total =
0.90 inches of immediate settlement
1.29 inches after 1 month
1.49 inches after 20 years
1.51 inches after 40 years

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STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET
▲5010.65

CALCULATION IDENTIFICATION NUMBER
J.O. OR W.O. NO. 05996.01
DIVISION & GROUP G(B)
CALCULATION NO. 07-1
OPTIONAL TASK CODE

STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE
05996.01	G(B)	07-1		D27

CALCULATION IDENTIFICATION NUMBER

A 5010.65

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

$q =$ 2.00 ksf $\gamma_t =$ 80.00 pcf GWT > 100 ft below grade ρ_{total} 1.52 "

$B =$ 10.00 ft $L =$ 10.00 ft (Square)

$D_f =$ 6.00 ft $E_{max} =$ 3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	5.00	8.50	0.68	2.50	2.00	2.00	0.232	0.93	1.41	2.09
1B	5.00	13.50	1.08	7.50	0.67	0.67	0.121	0.48	0.74	1.82
1C	5.00	18.50	1.48	12.50	0.40	0.40	0.060	0.24	0.37	1.85
1D	9.00	25.50	2.04	19.50	0.26	0.26	0.028	0.11	0.17	2.21

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, $b = B/2$ $n = l/z_{ftg}$, where $l = L/2$

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	5.00	1.41	0.075	0.50	1883	0.075	0.05
1B	5.00	0.74	0.028	0.71	2690	0.027	0.02
1C	5.00	0.37	0.010	0.86	3262	0.011	0.01
1D	9.00	0.17	0.005	0.91	3455	0.005	0.01
						Total =	0.07 inches

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., $E = 2 \times (1+\mu)$ G

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	5.00	0.68	2.09	0.41
1B	5.00	1.08	1.82	0.19
1C	5.00	1.48	1.85	0.08
1D	9.00	2.04	2.21	0.05
			Total =	0.73 inches

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times$ RR $\times$ Log $(\sigma_{vf}/\sigma_{vo})$

Note: 6.00 ksf = Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

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STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE
05996.01	G(B)	07-1		D28

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} 1.52 "

q =	2.00 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	10.00 ft	L =	10.00 ft (Square)	
D_f =	6.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32 = Log_{10}(40 yrs x 525,960 min/yr)
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month Inches	Log Cycles in 20 Yrs Inches	Log Cycles in 40 Yrs Inches
1A	5.00	2.09	0.35	0.035	0.10	0.15	0.15
1B	5.00	1.82	0.30	0.030	0.08	0.13	0.13
1C	5.00	1.85	0.31	0.031	0.09	0.13	0.14
1D	9.00	2.21	0.37	0.037	0.18	0.28	0.29
				Total =	0.45	0.68	0.71 inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	5.00	8.50	2.50	0.05	0.41	0.10	0.15	0.15
1B	5.00	13.50	7.50	0.02	0.19	0.08	0.13	0.13
1C	5.00	18.50	12.50	0.01	0.08	0.09	0.13	0.14
1D	9.00	25.50	19.50	0.01	0.05	0.18	0.28	0.29
			Total =	0.07	0.73	0.45	0.68	0.71 inches

Total = **0.81 inches of immediate settlement**
1.26 inches after 1 month
1.49 inches after 20 years
1.52 inches after 40 years

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

q = 8.70 ksf	γ_t = 80.00 pcf	GWT > 100 ft below grade		ρ_{total}
B = 1.30 ft	L = 1.30 ft (Square)			1.49 "
D_f = 8.00 ft	E_{max} = 3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1			

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	0.65	8.33	0.67	0.32	2.00	2.00	0.232	0.93	7.49	8.16
1B	0.65	8.98	0.72	0.98	0.67	0.67	0.121	0.48	3.90	4.62
1C	1.30	9.95	0.80	1.95	0.33	0.33	0.045	0.18	1.44	2.24
1D	1.30	11.25	0.90	3.25	0.20	0.20	0.018	0.07	0.58	1.48

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, b=B/2 $n = l/z_{ftg}$, where l=L/2

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$	= ΔH x 12 in./ft x ε_{actual}
	ft	ksf	%		ksf	%	inches	
1A	0.65	7.49	1.000	0.08	314	2.389	0.19	E/E_{max} = 0.083 for ε > 1 %
1B	0.65	3.90	1.000	0.08	314	1.244	0.10	
1C	1.30	1.44	0.080	0.48	1828	0.079	0.01	
1D	1.30	0.58	0.020	0.76	2877	0.020	0.00	
						Total =	0.30	inches

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., E = 2 x (1+μ) G

PRIMARY CONSOLIDATION SETTLEMENTS:

$\Delta\rho_{primary}$ = [ΔH x 12 in./ft] x [RR x Log ($\sigma_{mpp} / \sigma_{vo}$) + CR x Log ($\sigma_{vf} / s_{mpp}$)]

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	0.65	0.67	8.16	0.41
1B	0.65	0.72	4.62	0.09
1C	1.30	0.80	2.24	0.10
1D	1.30	0.90	1.48	0.05
			Total =	0.64 inches

Note:
6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1
0.294 = CR, See p 4 Calc 05996.01-G(B)-05, Rev 0
0.014 = RR, See p 4 Calc 05996.01-G(B)-05, Rev 0

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

q =	8.70 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade	ρ_{total} 1.49 "
B =	1.30 ft	L =	1.30 ft (Square)		
D_f =	8.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32	= Log_{10}(40 yrs x 525,960 min/yr)
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month inches	Log Cycles in 20 Yrs inches	Log Cycles in 40 Yrs inches	
1A	0.65	8.16	1.36	0.697	0.25	0.38	0.40	
1B	0.65	4.62	0.77	0.139	0.05	0.08	0.08	
1C	1.30	2.24	0.37	0.037	0.03	0.04	0.04	
1D	1.30	1.48	0.25	0.027	0.02	0.03	0.03	
				Total =	0.35	0.53	0.55	inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs	
	ft	ft	ft	inches	inches	inches	inches	inches	
1A	0.65	8.33	0.32	0.19	0.41	0.25	0.38	0.40	
1B	0.65	8.98	0.98	0.10	0.09	0.05	0.08	0.08	
1C	1.30	9.95	1.95	0.01	0.10	0.03	0.04	0.04	
1D	1.30	11.25	3.25	0.00	0.05	0.02	0.03	0.03	
			Total =	0.30	0.64	0.35	0.53	0.55	inches

Total = 0.94 inches of immediate settlement

1.29 inches after 1 month

1.47 inches after 20 years

1.49 inches after 40 years

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE
05996.01	G(B)	07-1		D31

5010.65

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} 1.50 "

q = 6.80 ksf	γ_t = 80.00 pcf		GWT > 100 ft below grade	
B = 2.00 ft	L = 2.00 ft (Square)			
D_f = 8.00 ft	E_{max} = 3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1			

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	1.00	8.50	0.68	0.50	2.00	2.00	0.232	0.93	5.73	6.41
1B	1.00	9.50	0.76	1.50	0.67	0.67	0.121	0.48	2.98	3.74
1C	4.00	12.00	0.96	4.00	0.25	0.25	0.027	0.11	0.67	1.63
1D	4.00	16.00	1.28	8.00	0.13	0.13	0.007	0.03	0.18	1.46

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, b=B/2 $n = l/z_{ftg}$, where l=L/2

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$	$= \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$
	ft	ksf	%		ksf	%	inches	
1A	1.00	5.73	1.000	0.08	314	1.826	0.22	E/E_{max} = 0.083 for ε > 1 %
1B	1.00	2.98	0.550	0.14	543	0.549	0.07	
1C	4.00	0.67	0.025	0.73	2753	0.024	0.01	
1D	4.00	0.18	0.005	0.91	3455	0.005	0.00	
						Total =	0.30	inches

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., E = 2 x (1+μ) G

PRIMARY CONSOLIDATION SETTLEMENTS:

$\Delta\rho_{primary}$ = [ΔH x 12 in./ft] x [RR x Log ($\sigma_{mpp} / \sigma_{vo}$) + CR x Log ($\sigma_{vf} / \sigma_{mpp}$)]

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	1.00	0.68	6.41	0.26
1B	1.00	0.76	3.74	0.12
1C	4.00	0.96	1.63	0.15
1D	4.00	1.28	1.46	0.04
			Total =	0.57 inches

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.294 = CR, See p 4 Calc 05996.01-G(B)-05, Rev 0

0.014 = RR, See p 4 Calc 05996.01-G(B)-05, Rev 0

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APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} 1.50 "

q =	6.80 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	2.00 ft	L =	2.00 ft (Square)	
D_f =	8.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month inches	Log Cycles in 20 Yrs inches	Log Cycles in 40 Yrs inches
1A	1.00	6.41	1.07	0.414	0.23	0.35	0.36
1B	1.00	3.74	0.62	0.081	0.05	0.07	0.07
1C	4.00	1.63	0.27	0.029	0.06	0.10	0.10
1D	4.00	1.46	0.24	0.027	0.06	0.09	0.10
				Total =	0.40	0.61	0.63 inches

= Log_{10}(40 yrs x 525,960 min/yr)

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = $\frac{525{,}960 \text{ min/yr}}{12 \text{ months/yr}}$

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	1.00	8.50	0.50	0.22	0.26	0.23	0.35	0.36
1B	1.00	9.50	1.50	0.07	0.12	0.05	0.07	0.07
1C	4.00	12.00	4.00	0.01	0.15	0.06	0.10	0.10
1D	4.00	16.00	8.00	0.00	0.04	0.06	0.09	0.10
			Total =	0.30	0.57	0.40	0.61	0.63 inches

Total = **0.87 inches of immediate settlement**
1.27 inches after 1 month
1.47 inches after 20 years
1.50 inches after 40 years

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STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET

5010.65

J.O. OR W.O. NO. 05996.01
DIVISION & GROUP G(B)
CALCULATION IDENTIFICATION NUMBER
CALCULATION NO. 07-1
OPTIONAL TASK CODE

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

					ρ_{total}
$q =$	5.60 ksf	$\gamma_t =$	80.00 pcf	GWT > 100 ft below grade	1.51 "
$B =$	3.00 ft	$L =$	3.00 ft (Square)		
$D_f =$	8.00 ft	$E_{max} =$	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	1.50	8.75	0.70	0.75	2.00	2.00	0.232	0.93	4.61	5.31
1B	1.50	10.25	0.82	2.25	0.67	0.67	0.121	0.48	2.40	3.22
1C	4.00	13.00	1.04	5.00	0.30	0.30	0.037	0.15	0.74	1.78
1D	4.00	17.00	1.36	9.00	0.17	0.17	0.013	0.05	0.25	1.61

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, $b = B/2$ $n = l/z_{ftg}$, where $l = L/2$

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$	$= \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$
	ft	ksf	%		ksf	%	inches	
1A	1.50	4.61	1.000	0.08	314	1.470	0.26	E/E_{max} = 0.083 for ε > 1 %
1B	1.50	2.40	0.300	0.21	796	0.302	0.05	
1C	4.00	0.74	0.028	0.71	2690	0.028	0.01	
1D	4.00	0.25	0.007	0.89	3362	0.007	0.00	
						Total =	0.34	inches

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., $E = 2 \times (1+\mu)\, G$

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	1.50	0.70	5.31	0.22
1B	1.50	0.82	3.22	0.15
1C	4.00	1.04	1.78	0.16
1D	4.00	1.36	1.61	0.05
			Total =	0.58 inches

$\Delta\rho_{primary} = [\Delta H \times 12 \text{ in./ft}] \times [RR \times \text{Log}(\sigma_{mpp} / \sigma_{vo}) + CR \times \text{Log}(\sigma_{vf} / s_{mpp})]$

Note:
6.00 ksf = Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1
0.294 = CR, See p 4 Calc 05996.01-G(B)-05, Rev 0
0.014 = RR, See p 4 Calc 05996.01-G(B)-05, Rev 0

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STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE
05996.01	G(B)	07-1	

5010.65

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} 1.51 "

q =	5.60 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	3.00 ft	L =	3.00 ft (Square)	
D_f =	8.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32	= Log_{10}(40 yrs x 525,960 min/yr)
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month inches	Log Cycles in 20 Yrs inches	Log Cycles in 40 Yrs inches	
1A	1.50	5.31	0.89	0.238	0.20	0.30	0.31	
1B	1.50	3.22	0.54	0.062	0.05	0.08	0.08	
1C	4.00	1.78	0.30	0.030	0.07	0.10	0.10	
1D	4.00	1.61	0.27	0.028	0.06	0.10	0.10	
				Total =	0.38	0.58	0.60	inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs	
	ft	ft	ft	inches	inches	inches	inches	inches	
1A	1.50	8.75	0.75	0.26	0.22	0.20	0.30	0.31	
1B	1.50	10.25	2.25	0.05	0.15	0.05	0.08	0.08	
1C	4.00	13.00	5.00	0.01	0.16	0.07	0.10	0.10	
1D	4.00	17.00	9.00	0.00	0.05	0.06	0.10	0.10	
			Total =	0.34	0.58	0.38	0.58	0.60	inches

Total = **0.91 inches of immediate settlement**
1.29 inches after 1 month
1.49 inches after 20 years
1.51 inches after 40 years

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STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE
05996.01	G(B)	07-1		D34

5010.65

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} = 1.51 "

q =	4.70 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	4.00 ft	L =	4.00 ft (Square)	
D_f =	8.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	2.00	9.00	0.72	1.00	2.00	2.00	0.232	0.93	3.78	4.50
1B	2.00	11.00	0.88	3.00	0.67	0.67	0.121	0.48	1.97	2.85
1C	4.00	14.00	1.12	6.00	0.33	0.33	0.045	0.18	0.73	1.85
1D	4.00	18.00	1.44	10.00	0.20	0.20	0.018	0.07	0.29	1.73

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m=b/z_{ftg}$, b=B/2 $n = l/z_{ftg}$, where l=L/2

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$	= ΔH x 12 in./ft x ε_{actual}
	ft	ksf	%		ksf	%	Inches	
1A	2.00	3.78	1.000	0.08	314	1.203	0.29	E/E_{max} = 0.083 for ε > 1 %
1B	2.00	1.97	0.150	0.35	1326	0.148	0.04	
1C	4.00	0.73	0.025	0.73	2753	0.026	0.01	
1D	4.00	0.29	0.010	0.86	3262	0.009	0.00	
						Total =	0.34	Inches

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., E = 2 x (1+μ) G

PRIMARY CONSOLIDATION SETTLEMENTS:

$\Delta\rho_{primary}$ = [ΔH x 12 in./ft] x [RR x Log ($\sigma_{mpp} / \sigma_{vo}$) + CR x Log ($\sigma_{vf} / s_{mpp}$)]

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	2.00	0.72	4.50	0.27
1B	2.00	0.88	2.85	0.17
1C	4.00	1.12	1.85	0.15
1D	4.00	1.44	1.73	0.05
			Total =	0.64 inches

Note:
6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1
0.294 = CR, See p 4 Calc 05996.01-G(B)-05, Rev 0
0.014 = RR, See p 4 Calc 05996.01-G(B)-05, Rev 0

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STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE
05996.01	G(B)	07-1		D35

5010.65

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

q =	4.70 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade	ρ_{total} 1.51 "
B =	4.00 ft	L =	4.00 ft (Square)		
D_f =	8.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x $\log_{10}$(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32 = $\log_{10}$(40 yrs x 525,960 min/yr)
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month Inches	Log Cycles in 20 Yrs Inches	Log Cycles in 40 Yrs Inches
1A	2.00	4.50	0.75	0.128	0.14	0.22	0.23
1B	2.00	2.85	0.47	0.051	0.06	0.09	0.09
1C	4.00	1.85	0.31	0.031	0.07	0.10	0.11
1D	4.00	1.73	0.29	0.029	0.07	0.10	0.10
				Total =	0.33	0.50	0.53 inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = $\frac{525,960 \text{ min/yr}}{12 \text{ months/yr}}$

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	2.00	9.00	1.00	0.29	0.27	0.14	0.22	0.23
1B	2.00	11.00	3.00	0.04	0.17	0.06	0.09	0.09
1C	4.00	14.00	6.00	0.01	0.15	0.07	0.10	0.11
1D	4.00	18.00	10.00	0.00	0.05	0.07	0.10	0.10
			Total =	0.34	0.64	0.33	0.50	0.53 inches

Total = **0.98 inches of immediate settlement**
1.31 inches after 1 month
1.48 inches after 20 years
1.51 inches after 40 years

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

q =	3.50 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade	ρ_{total}	1.52 "
B =	6.00 ft	L =	6.00 ft (Square)			
D_f =	8.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1			

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	3.00	9.50	0.76	1.50	2.00	2.00	0.232	0.93	2.66	3.42
1B	3.00	12.50	1.00	4.50	0.67	0.67	0.121	0.48	1.38	2.38
1C	6.00	17.00	1.36	9.00	0.33	0.33	0.045	0.18	0.51	1.87
1D	6.00	23.00	1.84	15.00	0.20	0.20	0.018	0.07	0.20	2.04

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, b=B/2 $n = l/z_{ftg}$, where l=L/2

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E/E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$	$= \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$
	ft	ksf	%		ksf	%	inches	
1A	3.00	2.66	0.400	0.18	666	0.400	0.14	E/E_{max} = 0.083 for ε > 1 %
1B	3.00	1.38	0.070	0.51	1942	0.071	0.03	
1C	6.00	0.51	0.015	0.80	3037	0.017	0.01	
1D	6.00	0.20	0.005	0.91	3455	0.006	0.00	
						Total =	0.19	inches

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., E = 2 x (1+μ) G

PRIMARY CONSOLIDATION SETTLEMENTS:

$\Delta\rho_{primary}$ = [ΔH x 12 in./ft] x [RR x Log ($\sigma_{mpp} / \sigma_{vo}$) + CR x Log ($\sigma_{vf} / s_{mpp}$)]

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	3.00	0.76	3.42	0.33
1B	3.00	1.00	2.38	0.19
1C	6.00	1.36	1.87	0.14
1D	6.00	1.84	2.04	0.05
			Total =	0.71 inches

Note: 6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1
0.294 = CR, See p 4 Calc 05996.01-G(B)-05, Rev 0
0.014 = RR, See p 4 Calc 05996.01-G(B)-05, Rev 0

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STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE
05996.01	G(B)	07-1		D37

A 5010.65

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

q =	3.50 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade	ρ_{total} 1.52 "
B =	6.00 ft	L =	6.00 ft (Square)		
D_f =	8.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32	= Log_{10}(40 yrs x 525,960 min/yr)
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month Inches	Log Cycles in 20 Yrs Inches	Log Cycles in 40 Yrs Inches	
1A	3.00	3.42	0.57	0.069	0.12	0.17	0.18	
1B	3.00	2.38	0.40	0.040	0.07	0.10	0.10	
1C	6.00	1.87	0.31	0.031	0.10	0.16	0.16	
1D	6.00	2.04	0.34	0.034	0.11	0.17	0.18	
				Total =	0.40	0.60	0.63	inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs	
	ft	ft	ft	inches	inches	inches	inches	inches	
1A	3.00	9.50	1.50	0.14	0.33	0.12	0.17	0.18	
1B	3.00	12.50	4.50	0.03	0.19	0.07	0.10	0.10	
1C	6.00	17.00	9.00	0.01	0.14	0.10	0.16	0.16	
1D	6.00	23.00	15.00	0.00	0.05	0.11	0.17	0.18	
			Total =	0.19	0.71	0.40	0.60	0.63	inches

Total = **0.89 inches of immediate settlement**
1.29 inches after 1 month
1.50 inches after 20 years
1.52 inches after 40 years

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STONE & WEBSTER ENGINEERING CORPORATION
CALCULATION SHEET
5010.65

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE
05996.01	G(B)	07-1		D38

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} 1.52 "

q = 2.70 ksf $\quad \gamma_t$ = 80.00 pcf $\quad$ GWT > 100 ft below grade

B = 8.00 ft $\quad$ L = 8.00 ft (Square)

D_f = 8.00 ft $\quad E_{max}$ = 3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	4.00	10.00	0.80	2.00	2.00	2.00	0.232	0.93	1.92	2.72
1B	4.00	14.00	1.12	6.00	0.67	0.67	0.121	0.48	1.00	2.12
1C	6.00	19.00	1.52	11.00	0.36	0.36	0.052	0.21	0.43	1.95
1D	8.00	26.00	2.08	18.00	0.22	0.22	0.022	0.09	0.18	2.26

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\quad \Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $\quad I_{center} = 4 \times I_{corner}$ $\quad \sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, b=B/2 $\quad n = l/z_{ftg}$, where l=L/2

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	4.00	1.92	0.125	0.39	1466	0.131	0.06
1B	4.00	1.00	0.038	0.65	2465	0.040	0.02
1C	6.00	0.43	0.013	0.82	3116	0.014	0.01
1D	8.00	0.18	0.005	0.91	3455	0.005	0.00
						Total =	0.10 inches

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., E = 2 x (1+μ) G

PRIMARY CONSOLIDATION SETTLEMENTS:

$\Delta\rho_{primary} = [\Delta H \times 12 \text{ in./ft}] \times [RR \times \text{Log}(\sigma_{mpp} / \sigma_{vo}) + CR \times \text{Log}(\sigma_{vf} / s_{mpp})]$

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	4.00	0.80	2.72	0.36
1B	4.00	1.12	2.12	0.19
1C	6.00	1.52	1.95	0.11
1D	8.00	2.08	2.26	0.05
			Total =	0.70 inches

Note:
6.00 ksf =Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1
0.294 = CR, See p 4 Calc 05996.01-G(B)-05, Rev 0
0.014 = RR, See p 4 Calc 05996.01-G(B)-05, Rev 0

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} 1.52 "

q =	2.70 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	8.00 ft	L =	8.00 ft (Square)	
D_f =	8.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

= Log_{10}(40 yrs x 525,960 min/yr)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month Inches	Log Cycles in 20 Yrs Inches	Log Cycles in 40 Yrs Inches
1A	4.00	2.72	0.45	0.048	0.11	0.16	0.17
1B	4.00	2.12	0.35	0.035	0.08	0.12	0.12
1C	6.00	1.95	0.32	0.032	0.11	0.16	0.17
1D	8.00	2.26	0.38	0.038	0.17	0.25	0.26
				Total =	0.46	0.70	0.73 inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = $\frac{525,960 \text{ min/yr}}{12 \text{ months/yr}}$

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	4.00	10.00	2.00	0.08	0.36	0.11	0.16	0.17
1B	4.00	14.00	6.00	0.02	0.19	0.08	0.12	0.12
1C	6.00	19.00	11.00	0.01	0.11	0.11	0.16	0.17
1D	8.00	26.00	18.00	0.00	0.05	0.17	0.25	0.26
			Total =	0.10	0.70	0.46	0.70	0.73 inches

Total = **0.80 inches of immediate settlement**
1.26 inches after 1 month
1.49 inches after 20 years
1.52 inches after 40 years

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

ρ_{total} 1.48 "

q =	2.30 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	10.00 ft	L =	10.00 ft (Square)	
D_f =	8.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	5.00	10.50	0.84	2.50	2.00	2.00	0.232	0.93	1.54	2.38
1B	5.00	15.50	1.24	7.50	0.67	0.67	0.121	0.48	0.80	2.04
1C	5.00	20.50	1.64	12.50	0.40	0.40	0.060	0.24	0.40	2.04
1D	7.00	26.50	2.12	18.50	0.27	0.27	0.031	0.12	0.21	2.33

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, b=B/2 $n = l/z_{ftg}$, where l=L/2

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	5.00	1.54	0.090	0.46	1727	0.089	0.05
1B	5.00	0.80	0.030	0.70	2652	0.030	0.02
1C	5.00	0.40	0.014	0.81	3075	0.013	0.01
1D	7.00	0.21	0.006	0.90	3405	0.006	0.01
						Total =	0.08 inches

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., E = 2 x (1+μ) G

PRIMARY CONSOLIDATION SETTLEMENTS:

$\Delta\rho_{primary}$ = [ΔH x 12 in./ft] x [RR x Log ($\sigma_{mpp} / \sigma_{vo}$) + CR x Log ($\sigma_{vf} / s_{mpp}$)]

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	5.00	0.84	2.38	0.38
1B	5.00	1.24	2.04	0.18
1C	5.00	1.64	2.04	0.08
1D	7.00	2.12	2.33	0.05
			Total =	0.69 inches

Note: 6.00 ksf = Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.294 = CR, See p 4 Calc 05996.01-G(B)-05, Rev 0

0.014 = RR, See p 4 Calc 05996.01-G(B)-05, Rev 0

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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

A 5010.65

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO. 05996.01

DIVISION & GROUP G(B)

CALCULATION NO. 07-1

OPTIONAL TASK CODE

APPENDIX D

CALCULATION OF SETTLEMENTS BENEATH CENTER OF SQUARE FOOTING

q =	2.30 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade	ρ_{total} 1.48 "
B =	10.00 ft	L =	10.00 ft (Square)		
D_f =	8.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1		

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

= Log_{10}(40 yrs x 525,960 min/yr)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles In 1 month inches	Log Cycles In 20 Yrs Inches	Log Cycles In 40 Yrs Inches
1A	5.00	2.38	0.40	0.040	0.11	0.17	0.17
1B	5.00	2.04	0.34	0.034	0.09	0.14	0.15
1C	5.00	2.04	0.34	0.034	0.09	0.14	0.15
1D	7.00	2.33	0.39	0.039	0.15	0.23	0.24
				Total =	0.45	0.68	0.71 inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	5.00	10.50	2.50	0.05	0.38	0.11	0.17	0.17
1B	5.00	15.50	7.50	0.02	0.18	0.09	0.14	0.15
1C	5.00	20.50	12.50	0.01	0.08	0.09	0.14	0.15
1D	7.00	26.50	18.50	0.01	0.05	0.15	0.23	0.24
			Total =	0.08	0.69	0.45	0.68	0.71 inches

Total = **0.77 inches of immediate settlement**
1.22 inches after 1 month
1.45 inches after 20 years
1.48 inches after 40 years

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

$q =$	2.55 ksf	$\gamma_t =$	80.00 pcf	GWT > 100 ft below grade	ρ_{total}	2.00 "
$B =$	10.00 ft	$L =$	100 ft (Strip Footing; L>>B)			
$D_f =$	8.00 ft	$E_{max} =$	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1			

STRESSES BENEATH FOOTING:

LAYER	ΔH	z_{grade}	σ_{vo}	z_{ftg}	m	n	I_{corner}	I_{center}	$\Delta\sigma_v$	σ_{vf}
	ft	ft	ksf	ft					ksf	ksf
1A	5.00	10.50	0.84	2.50	2.00	20.00	0.240	0.96	1.83	2.67
1B	5.00	15.50	1.24	7.50	0.67	6.67	0.167	0.67	1.28	2.52
1C	5.00	20.50	1.64	12.50	0.40	4.00	0.115	0.46	0.88	2.52
1D	7.00	26.50	2.12	18.50	0.27	2.70	0.082	0.33	0.62	2.74

Note: $\sigma_{vo} = z_{grade} \times \gamma_t$ $\Delta\sigma_v = (q - \gamma_t D_f) \times I_{center}$ $I_{center} = 4 \times I_{corner}$ $\sigma_{vf} = \sigma_{vo} + \Delta\sigma_v$

I_{corner} = f(m & n) based on Fig 3.40 in Das(1995), where: $m = b/z_{ftg}$, $b = B/2$ $n = l/z_{ftg}$, where $l = L/2$

ELASTIC SETTLEMENTS:

LAYER	ΔH	$\Delta\sigma_v$	$\varepsilon_{assumed}$	E / E_{max}	E	ε_{actual}	$\Delta\rho_{elastic}$
	ft	ksf	%		ksf	%	inches
1A	5.00	1.83	0.125	0.39	1466	0.125	0.08
1B	5.00	1.28	0.062	0.54	2046	0.062	0.04
1C	5.00	0.88	0.034	0.68	2561	0.034	0.02
1D	7.00	0.62	0.022	0.75	2824	0.022	0.02
						Total =	0.15 inches

$\Delta\rho_{elastic} = \Delta H \times 12$ in./ft $\times \varepsilon_{actual}$

Note: $\varepsilon_{actual} = \Delta\sigma_v / E$

Assume: E / E_{max} Based on G/G_{max} from Geomatrix Calc 05996.01-G(P05)-1, Rev 0, p12/29 of Section 1.3

NOTE: E is directly related to G; i.e., $E = 2 \times (1+\mu)\, G$

PRIMARY CONSOLIDATION SETTLEMENTS:

LAYER	ΔH	σ_{vo}	σ_{vf}	$\Delta\rho_{primary}$
	ft	ksf	ksf	inches
1A	5.00	0.84	2.67	0.42
1B	5.00	1.24	2.52	0.26
1C	5.00	1.64	2.52	0.16
1D	7.00	2.12	2.74	0.13
			Total =	0.97 inches

$\Delta\rho_{primary} = \Delta H \times 12$ in./ft $\times RR \times \text{Log}(\sigma_{vf}/\sigma_{vo})$

Note: 6.00 ksf = Maximum past pressure from consolidation tests - See p 7 Calc 05996.01-G(B)-01, Rev 1

0.014 = RR, See p 13 Calc 05996.01-G(B)-03, Rev 1

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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO. 05996.01

DIVISION & GROUP G(B)

CALCULATION NO. 07 - 1

OPTIONAL TASK CODE

5010 65

APPENDIX C

CALCULATION OF SETTLEMENTS BENEATH CENTER OF STRIP FOOTING

ρ_{total} 2.00 "

q =	2.55 ksf	γ_t =	80.00 pcf	GWT > 100 ft below grade
B =	10.00 ft	L =	100 ft (Strip Footing; L>>B)	
D_f =	8.00 ft	E_{max} =	3780 ksf - From Table 1 Calc 05996.01-G(B)-01, Rev 1	

SECONDARY SETTLEMENTS:

Δ Secondary Settlement = 12 in./ft x C_α x Log_{10}(Δt in min)

= Log_{10}(40 yrs x 525,960 min/yr)

LAYER	ΔH	σ_{vf}	σ_{vf}/σ_{mpp}	C_α	4.64	7.02	7.32
	ft	ksf		%/Log Cycle Time (min)	Log Cycles in 1 month Inches	Log Cycles in 20 Yrs Inches	Log Cycles in 40 Yrs Inches
1A	5.00	2.67	0.45	0.047	0.13	0.20	0.21
1B	5.00	2.52	0.42	0.043	0.12	0.18	0.19
1C	5.00	2.52	0.42	0.043	0.12	0.18	0.19
1D	7.00	2.74	0.46	0.049	0.19	0.29	0.30
				Total =	0.56	0.85	0.88 inches

Note: C_α = rate of secondary compression & is f(σ_{vf}/σ_{mpp}) - From Figure 2 in Calc 05996.01-G(B)-05, Rev 0

525,960 min = 1 yr = 365.25 days x 24 hr/day x 60 min/hr

43,830 min/month = 525,960 min/yr / 12 months/yr

SUMMARY OF SETTLEMENTS:

LAYER	ΔH	z_{grade}	z_{ftg}	$\Delta\rho_{elastic}$	$\Delta\rho_{primary}$	Δ Secondary Settlement 1 month	20 yrs	40 yrs
	ft	ft	ft	inches	inches	inches	inches	inches
1A	5.00	10.50	2.50	0.08	0.42	0.13	0.20	0.21
1B	5.00	15.50	7.50	0.04	0.26	0.12	0.18	0.19
1C	5.00	20.50	12.50	0.02	0.16	0.12	0.18	0.19
1D	7.00	26.50	18.50	0.02	0.13	0.19	0.29	0.30
			Total =	0.15	0.97	0.56	0.85	0.88 inches

Total = **1.12 inches of immediate settlement**
1.68 inches after 1 month
1.97 inches after 20 years
2.00 inches after 40 years