SPREAD FOOTING DESIGN

Developed By

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FOR
OLIVETTI P602 with MLU600

Program No. 59

PROGRAM COMMENTARY

Program is designed so the engineer enters a trial footing size and external loads on the footing. Moment capacity is then computed for the footing, along with soil pressures. The program can take three separate paths, depending on moment and axial load ratio. After the correct data has been entered, the program will automatically select correct set of equations and solve the problem completely, without further help from the engineer.

Compressive strength of concrete f'_c is the 28-day strength.

The design constant "a" is used in computing required steel for footing in the equation $A_s = M/ad$. A guide for selecting "a" is :

$f_s = 16000$	$a = 1.13$
$f_s = 18000$	$a = 1.29$
$f_s = 20000$	$a = 1.44$
$f_s = 22000$	$a = 1.60$
$f_s = 24000$	$a = 1.76$

The value "a" can be computed as follows:

$$k = \frac{1}{1 + f_s/nf_c} \qquad j = 1 - k/3$$

$$a = f_s \text{ (Average j value)}/12000$$

The passive pressure factor c, Input Item #13, is equal to 1 if passive pressures are to be considered in the analysis and design. Thus, c = 1 for all block footings and footings where relatively undisturbed soil material will be against footing. If the value of c = 0 is entered, passive resistance will be neglected. When footing has no shear or moment , then c = 0.

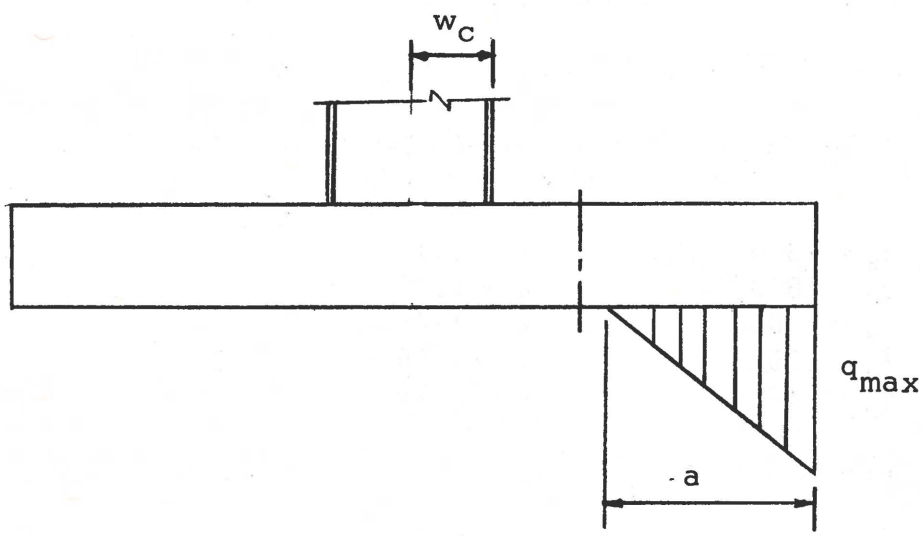
Punching shear is not computed when $q_{min} = 0.0$. Beam shear is computed in all cases.

Further reference can be made to the Schaum outline series, "Reinforced Concrete Design', by Everand and Tanner.

EQUATION USED

Case 1a

If $a < L/2 - w_c - d$



$M = M' + H(h) - .025WD^3c$ $\quad R = P + .15LWD \quad d = D - .33$

$q_{max} = 4R/[3W(L-2e)]$ $\quad q_{min} = 0.0$

$a = L/2 - e$ $\quad e = M/R$

For beam shear - $v = \dfrac{q_{max}(a)}{.288\ d}$

For moment - $M_4 = \dfrac{q_{max}(a)}{2}(L/2 - a/3 - w_c)$

$f = M/(.024D^2)$

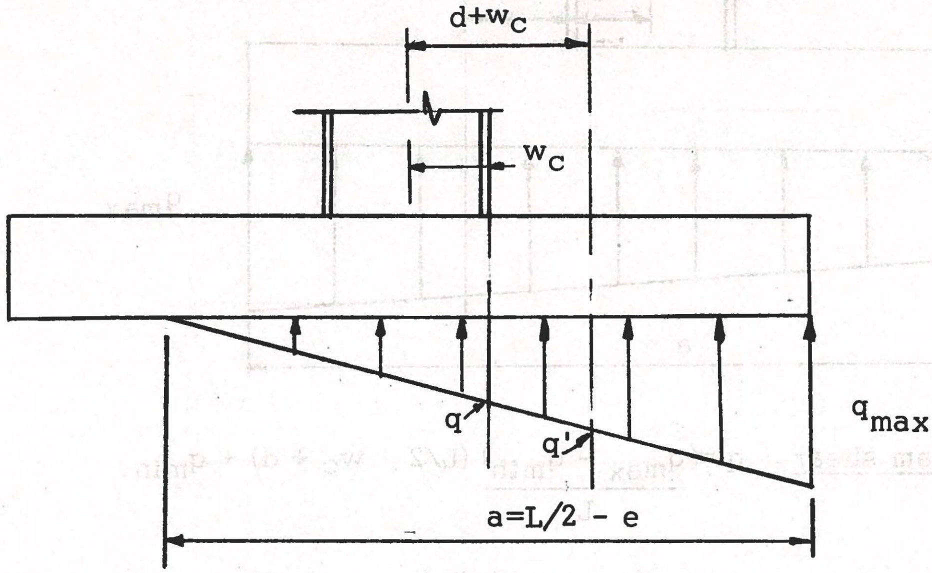
$M_2 = .01875D(L)^2$

$M_3 = .01875D(W)^2$

EQUATION USED

Case 1b

If $a \geqslant L/2 - w_c - d$



$M = M' + H(h) - .025WD^3c$ $\qquad R = P + .15WDL$

$q_{max} = 4R/[3W(L-2e)]$ $\qquad q_{min} = 0.0$

For shear $\qquad q' = \dfrac{q_{max}}{a}(a - L/2 + w_c + d)$ $\qquad e = M/R$

$v = \dfrac{(q_{max} + q')}{.288d}(L/2 - w_c - d)$ $\qquad d = D - .33$

For moment $\qquad q = \dfrac{q_{max}}{a}(a - L/2 + w_c)$ $\qquad M_4 = \dfrac{(2q_{max} + q)}{6}(L/2 - w_c)^2$

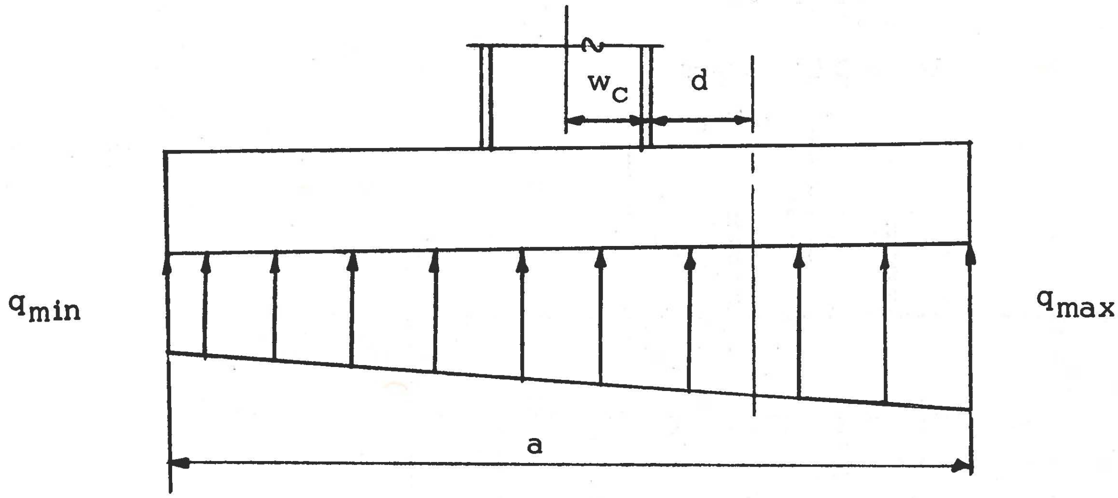
$f = M/(.024D^2)$

$M_2 = .01875D(L)^2$ $\qquad M_3 = .01875D(W)^2$

EQUATION USED

Program No. 59

Case 2



For shear - beam shear $q = \frac{(q_{max} - q_{min})}{L} (L/2 + w_c + d) + q_{min}$

$$v_{bm} = \frac{(q_{max} + q)}{.288d} (L/2 - w_c - d)$$

punching shear $V_1 + V_2 = W(L/2 - w_c - d/2)\ (q_{max} + q_{min})$

$$V_3 = (W - 2\,w_c - d)\ (q_{max} + q_{min})\ (d/2 + w_c)$$

$$v_p = \frac{V_1 + V_2 + V_3}{(2w_c + d)\ (.048)\ (12)d}$$

For moment $q = \frac{(q_{max} - q_{min})}{L} (L/2 + w_c) + q_{min}$

$M_1 = (L/2 - w_c)^2\ (q + 2q_{max})\ /6$ $\qquad f = M/(.024D^2)$

$q_{max} = R/WL + 6M/W\ (L)^2$ $\qquad a = L$ $\qquad M = M' + H(h) - .025WD^3\ c$

$q_{min} = R/WL - 6M/W\ (L)^2$ $\qquad d = D - .33$

$M_2 = .01875D\ (L)^2$ $\qquad M_3 = .01875D\ (W)^2$

COMPUTER INSTRUCTIONS

Program: Spread Footing Design

Program No. 59

Upper Decimal Wheel 0

Lower Decimal Wheel 4

INPUT

1. Turn P602 on.
2. Turn MLU600 on.
3. Depress "Reset" Key on P602
4. Depress "Reset" Key on MLU600
5. Call Block 59 and depress "V"
6. Enter length of footing (ft.)
7. Depress "S"
8. Enter width of footing (ft.)
9. Depress "S"
10. Enter depth of footing (ft.)
11. Depress "S"
12. Enter horizontal shear at top of footing (kips)
13. Depress "S"
14. Enter distance from shear to bottom of footing (ft.)
15. Depress "S"

--Continued--

OUTPUT

1. Eccentricity (ft.)
2. Moment capacity based on soil pressue (k-ft.)
3. Moment capacity based on overturning factor of safety (k-ft.)
4. Actual moment on footing (k-ft.)
5. Actual eccentricity (ft.)
6. Maximum soil pressure (ksf)
7. Minimum soil pressure (ksf)
8. Length of soil pressure diagram (ft.)

See Page 7 of 17 for remaining output identification.

INPUT

16. Enter applied moment (k-ft.)

17. Depress "S"

18. Enter vertical load, excluding footing weight (kips)

19. Depress "S"

20. Enter compressive strength of concrete (psi)

21. Depress "S"

22. Enter design constant "a"

23. Depress "S"

24. Enter half of column width

25. Depress "S"

26. Enter soil pressure (ksf)

27. Depress "S"

28. Enter overturning safety factor

29. Depress "S"

30. Enter passive soil pressure factor (c)

    If c = 1, passive pressure considered

    If c = 0, passive pressure neglected

31. Depress "S"

OUTPUT

If $q_{min} = 0.0$

9. Allowable beam shearing stress (psi)
10. Actual beam shearing stress (psi)
11. Effective depth of footing(ft.)
12. Allowable tensile stress in footing (psi)
13. Moment due to soil pressure (k-ft.) bottom
14. Tensile stress (psi)
15. Area of steel required per foot (in.^{2}) bottom
16. Moment long direction top (k-ft.)
17. Tensile stress (psi)
18. Area of steel required per foot (in.^{2})
19. Moment width direction top (k-ft.)
20. Tensile stress (psi)
21. Area of steel required per foot (in.^{2})

If $q_{min} > 0.0$

9. Allowable punching stress w/o steel (psi)
10. Allowable punching stress with steel (psi)
11. Actual punching stress (psi)
12. Allowable beam shearing stress (psi)
13. Actual beam shearing stress (psi)
14. Effective depth of footing (ft.)
15. Allowable tensile stress in concrete (psi)
16. Moment due to soil pressure (k-ft.) bottom
17. Tensile stress (psi)
18. Area of steel required per foot (in.^{2}) bottom
19. Moment long direction top (k-ft.)
20. Tensile stress (psi)
21. Area of steel required per foot (in.^{2})
22. Moment width direction top (k-ft.)
23. Tensile stress (psi)
24. Area of steel required per foot (in.^{2})

EXAMPLE PROBLEM

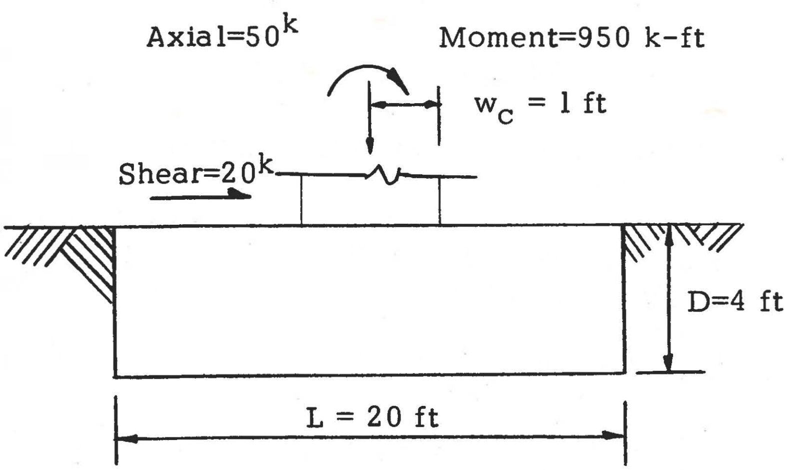
Given:

Try footing L x W x D
20 x 10 x 4

f'_c = 5000 psi f_s = 2000 spi

a = 1.44   h = 4.0 ft.

Loads   Moment = 950 k-ft.   Axial = 50 k.
Shear = 20 k.   c = 1.0
Allowable soil pressure = 3 ksf
Safety factor against overturning = 1.5



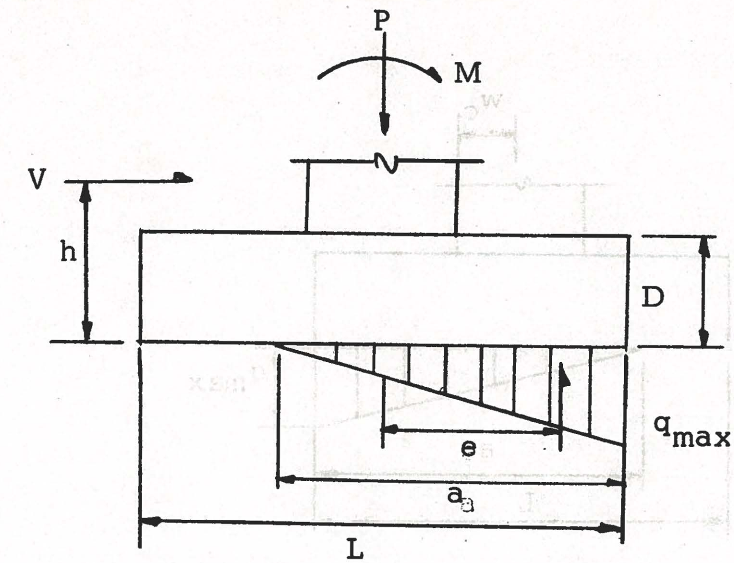
Conclusions

Actual moment = 1014 k-ft.
Moment capacity = 1057 k-ft. (S.P. = 3 ksf)
Moment capacity = 1133 k-ft. (OTSF = 1.5)
Footing has required moment capacity.

Maximum soil pressure = 2.81 ksf
Beam shearing stress = 21.9 psi $<$ 77.8 psi
Area of steel required in bottom = 1.34 in.^{2}
Use #9 at 9 in. centers
Area steel top = .473   Use #6 @ 10 in. centers
Area steel width top = .118   Use #4 @ 12 in. centers

FOOTING DESIGN

Program No. 59 — Case 1a



Data

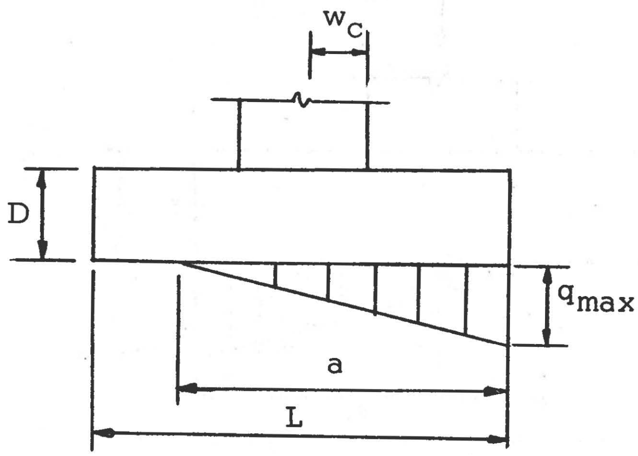
Length of Foundation (L)	=	20	ft.
Width of Foundation (W)	=	10	ft.
Depth of Foundation (D)	=	4	ft.
Horizontal Shear (V)	=	20	k.
Distance to Shear (h)	=	4	ft.
Applied Moment (M)	=	950	k-ft.
Vertical Force (P)	=	0	k.
Compressive Strength of Concrete (f'_c)	=	5000	psi
Design Constant (a)	=	1.44	
Half Column Width (W_c)	=	1	ft.

Calculations

For Soil Pressure (Q)		3	ksf
$e = L/2 - 2(.15LWD + P)/(3WQ)$	=	7.3334	ft.
Moment Capacity $M_c = R(e)$	=	880.0080	k-ft.
$R = .15LWD + P$			
For Safety Factor (SF)	=	1.5	
Moment Capacity $M_c = RL / 2SF$	=	800.0000	k-ft.
Passive Soil Pressure Factor (c)			
Moment Actual $= M + Vh - .025WD^3(c)$	=	1014.0000	k-ft.
Actual Eccentricity $E = M_{act}/R$	=	8.4500	ft.
Maximum Soil Pressure (q_{max})	=	5.1612	ksf.
Minimum Soil Pressure (q_{min})	=	0.0000	ksf.
Length of Pressure Diagram (a)	=	4.6500	ft.

FOOTING DESIGN

Program No. 59 — Case 1a



Beam Shear Analysis

Allowable beam shearing stress $= \sqrt{f'_c}\,(1.1)$	=	77.7816	psi
Actual shearing stress in concrete v	=	22.5493	psi
Effective depth of footing (d)	=	3.6700	ft.
Allowable tensile stress in concrete $= 1.6\sqrt{f'_c}$	=	113.1369	psi

Bottom Steel Design

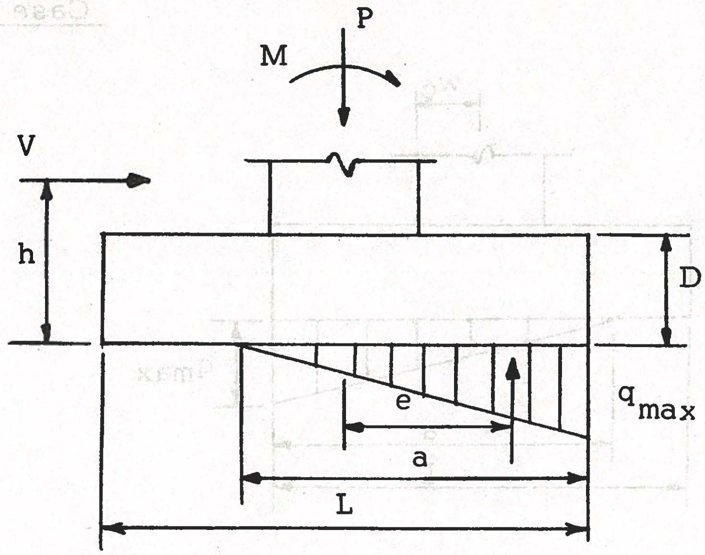
Moment due to soil pressure M_4	=	89.3983	k-ft.
Tensile stress	=	232.8080	psi
Area of steel required per foot by M_4	=	1.4096	in.^{2}

Top Steel Design

Moment long direction M_2	=	30.0018	k-ft.
Tensile stress	=	78.1296	psi
Area of steel required per foot by M_2	=	0.4730	in.^{2}
Moment in width direction M_3	=	7.5004	k-ft.
Tensile stress	=	19.5322	psi
Area of steel required per foot by M_3	=	0.1182	in.^{2}

FOOTING DESIGN

Program No. 59 **Case 1b**



Data

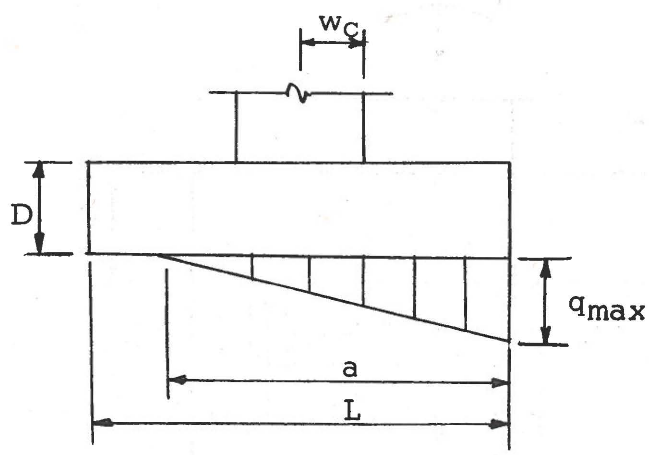
Length of Foundation (L)	=	20	ft.
Width of Foundation (W)	=	10	ft.
Depth of Foundation (D)	=	4	ft.
Horizontal Shear (V)	=	20	k.
Distance to Shear (h)	=	4	ft.
Applied Moment (M)	=	950	k-ft.
Vertical Force (P)	=	50	k.
Compressive Strength of Concrete (f'_c)	=	5000	psi
Design Constant (a)	=	1.44	
Half Column Width (W_c)	=	1	ft.

Calculations

For Soil Pressure (Q)	=	3	ksf
$e = L/2 - 2(.15LWD + P)/(3WQ)$	=	6.2223	ft.
Moment Capacity $M_c = R(e)$	=	1057.7910	k-ft.
$R = .15LWD + P$			
For Safety Factor (SF)	=		
Moment Capacity $M_c = RL / 2\ SF$	=	1.5	k-ft.
Passive Soil Pressure Factor (c)	=	1133.3333	
Moment Actual $= M + Vh - .025WD^3(c)$	=		k-ft.
		1014.0000	
Actual Eccentricity $E = M_{act}/R$	=		ft.
		5.9647	
Maximum Soil Pressure (q_{max})	=		ksf
		2.8085	
Minimum Soil Pressure (q_{min})	=		ksf
		0.0000	
Length of Pressure Diagram (a)	=		ft.
		12.1059	

FOOTING DESIGN

Program No. 59 | Case 1b



Beam Shear Analysis

Allowable beam shearing stress = $\sqrt{f'_c}$ (1.1)	=	77.7816	psi
Actual shearing stress in concrete v	=	21.9366	psi
Effective depth of footing (d)	=	3.6700	ft.
Allowable tensile stress in concrete = 1.6 $\sqrt{f'_c}$	=	113.1369	psi

Bottom Steel Design

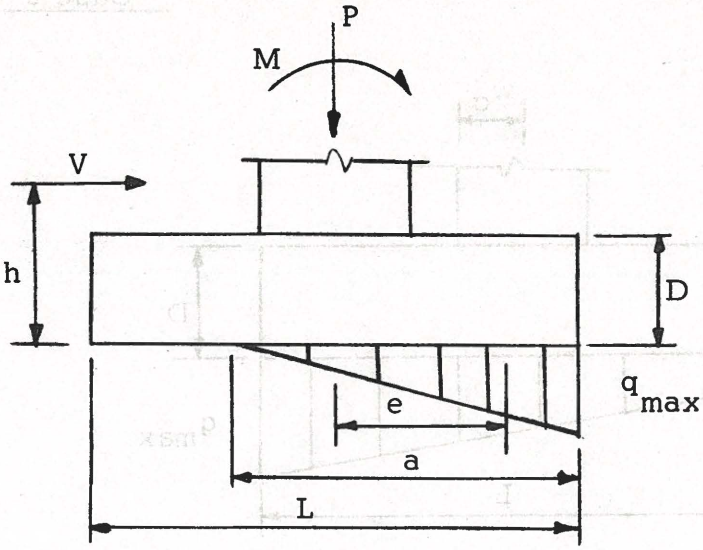
Moment due to soil pressure M_4	=	85.5522	k-ft.
Tensile stress	=	222.7921	psi
Area of steel required per foot by M_4	=	1.3490	in.^{2}

Top Steel Design

Moment long direction M_2	=	30.0018	k-ft.
Tensile stress	=	78.1296	psi
Area of steel required per foot by M_2	=	0.4730	in.^{2}
Moment in width direction M_3	=	7.5004	k-ft.
Tensile stress	=	19.5322	psi
Area of steel required per foot by M_3	=	0.1182	in.^{2}

FOOTING DESIGN

Program No. 59 | Case 2



Data

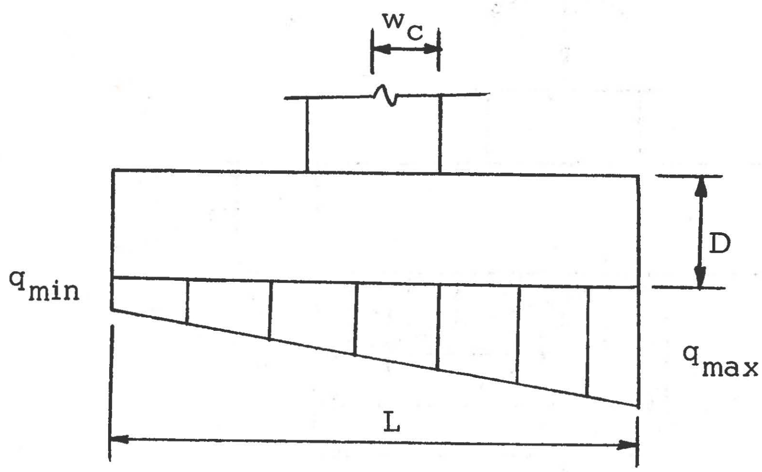
Length of Foundation (L)	=	20	ft.
Width of Foundation (W)	=	10	ft.
Depth of Foundation (D)	=	4	ft.
Horizontal Shear (V)	=	20	k.
Distance to Shear (h)	=	4	ft.
Applied Moment (M)	=	200	k-ft.
Vertical Force (P)	=	295	k.
Compressive Strength of Concrete (f'_c)	=	5000	psi
Design Constant (a)	=	1.44	
Half Column Width (W_c)	=	1	ft.

Calculations

For Soil Pressure (Q)	=	3	ksf
$e = L/2 - 2(.15LWD + P) / (3WQ)$	=	0.7778	ft.
Moment Capacity $M_c = R(e)$	=	322.7870	k-ft.
$R = .15LWD + P$			
For Safety Factor (SF)	=	1.5	
Moment Capacity $M_c = RL / 2SF$	=	2766.6666	k-ft.
Passive Soil Pressure Factor (c)	=		
Moment Actual $= M + Vh - .025WD^3(c)$	=	264.0000	k-ft.
Actual Eccentricity $E = M_{act}/R$	=	0.6361	ft.
Maximum Soil Pressure (q_{max})	=	2.4950	ksf
Minimum Soil Pressure (q_{min})	=	1.6550	ksf
Length of Pressure Diagram (a)	=	20.0000	ft.

FOOTING DESIGN

Program No. 59 — Case 2



Punching Shear Analysis

Allowable punching shear w/o reinforcement = $2\sqrt{f'_c}$	=	141.4212	psi
Allowable punching shear with reinforcement = $3\sqrt{f'_c}$	=	212.1318	psi
Actual punching shear v_p	=	29.0586	psi

Beam Shear Analysis

Allowable beam shearing stress = $1.1\sqrt{f'_c}$	=	77.7816	psi
Actual beam shearing stress = $(L/2-w_c-d)(q_{max}+q)/.29d$	=	23.8672	psi

Where $q = (q_{max} - q_{min})(L/2 + w_c + d)/L + q_{min}$

Effective depth of footing (d)	=	3.6700	ft.
Allowable tensile stress in concrete = $1.6\sqrt{f'_c}$	=	113.1369	psi

Bottom Steel Design

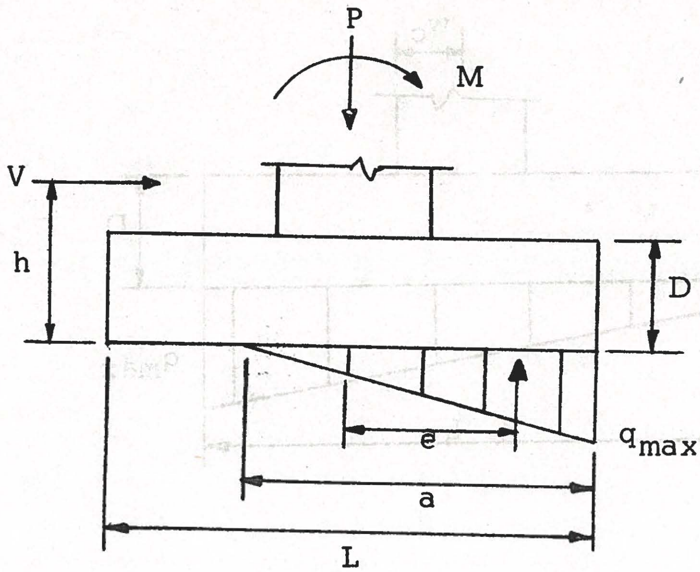
Moment due to soil pressure M_1	=	95.9445	k-ft.
Tensile stress	=	249.8554	psi
Area of steel required per foot by M_1	=	1.5129	$in.^2$

Top Steel Design

Moment long direction M_2	=	30.0018	k-ft.
Tensile stress	=	78.1296	psi
Area of steel required per foot by M_2	=	0.1730	$in.^2$
Moment in width direction M_3	=	7.5004	k-ft.
Tensile stress	=	19.5322	psi
Area of steel required per foot by M_3	=	0.1182	$in.^2$

FOOTING DESIGN

Program No. 59



Data

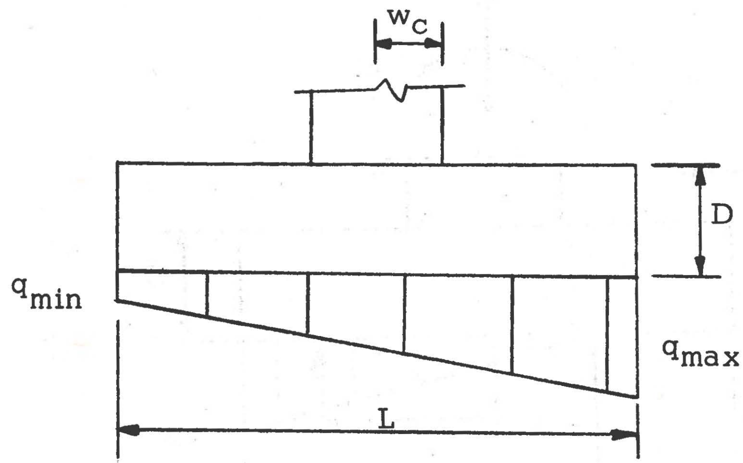
Length of Foundation (L)	=	ft.
Width of Foundation (W)	=	ft.
Depth of Foundation (D)	=	ft.
Horizontal Shear (V)	=	k.
Distance to Shear (h)	=	ft.
Applied Moment (M)	=	k-ft.
Vertical Force (P)	=	k.
Compressive Strength of Concrete (f'_c)	=	psi
Design Constant (a)	=	
Half Column Width (W_c)	=	ft.

Calculations

For Soil Pressure (Q)	=	ksf
e = L/2 - 2(.15LWD + P) /(3WQ)	=	ft.
Moment Capacity M_c = R (e)	=	k-ft.
R = .15LWD + P		
For Safety Factor (SF)	=	
Moment Capacity M_c = RL/2SF	=	k-ft.
Passive Soil Pressure Factor (c)		
Moment Actual = M + Vh - .025WD^3(c)	=	k-ft.
Actual Eccentricity E = M_{act}/R	=	ft.
Maximum Soil Pressure (q_{max})	=	ksf
Minimum Soil Pressure (q_{min})	=	ksf
Length of Pressure Diagram (a)	=	ft.

FOOTING DESIGN

Program No. 59



Punching Shear Analysis

Allowable punching shear w/o reinforcement = $2\sqrt{f'_c}$	=		psi
Allowable punching shear with reinforcement = $3\sqrt{f'_c}$	=		psi
Actual punching shear v_p	=		psi

Beam Shear Analysis

Allowable beam shearing stress = $1.1\sqrt{f'_c}$	=		psi
Actual beam shearing stress = $(L/2-w_c-d)(q_{max}+q).29d$	=		psi

Where $q = (q_{max} - q_{min})\ (L/2+w_{c+d})/L + q_{min}$

Effective depth of footing (d)	=		ft.
Allowable tensile stress in concrete = $1.6\sqrt{f'_c}$	=		psi

Bottom Steel Design

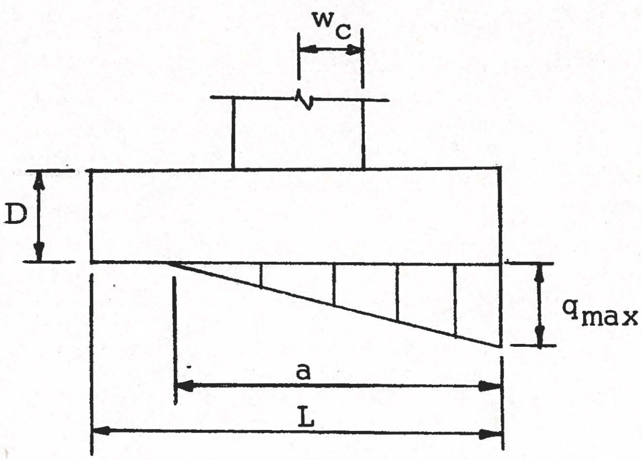
Moment due to soil pressure M_1	=		k-ft.
Tensile stress	=		psi
Area of steel required per foot by M_1	=		$in.^2$

Top Steel Design

Moment long direction M_2	=		k-ft.
Tensile stress	=		psi
Area of steel required per foot by M_2	=		$in.^2$
Moment in width direction M_3	=		k-ft.
Tensile stress	=		psi
Area of steel required per foot by M_3	=		$in.^2$

FOOTING DESIGN

Program No. 59



Beam Shear Analysis

Allowable beam shearing stress = $\sqrt{f'_c}$ (1.1)	=		psi
Actual shearing stress in concrete v	=		psi
Effective depth of footing d	=		ft.
Allowable tensile stress in concrete = $1.6\sqrt{f'_c}$	=		psi

Bottom Steel Design

Moment due to soil pressure M_4	=		k-ft.
Tensile stress	=		psi
Area of steel required per foot by M_4	=		$in.^2$

Top Steel Design

Moment long direction M_2	=		k-ft.
Tensile stress	=		psi
Area of steel required per foot by M_2	=		$in.^2$
Moment in width direction M_3	=		k-ft.
Tensile stress	=		psi
Area of steel required per foot by M_3	=		$in.^2$