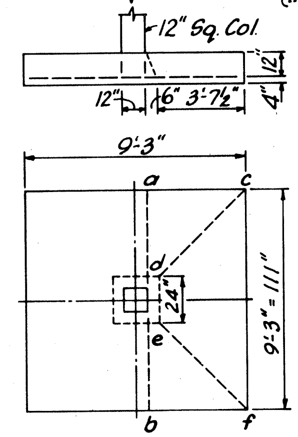
DP 23-1
Building Footings
Sh. 1 of 2

Footing Design. Structural.

Interior: (See DP 18-1 Shs. 1 & 2)

$P_u = 245.5^K \begin{cases} 1.4(83.8) \\ 1.7(75.4) \end{cases}$ (Load factors = 1.4 DL + 1.7 LL)



Capacity factors, $\phi = 0.90$ (flexure) $= 0.85$ (shear)

$f'_c = 4{,}000$ psi
$\times 0.85 = 3{,}400$ psi (stress block)

$v_c = 4\sqrt{4{,}000} = 253$ psi (2-way)
$\times 0.85 = 215$ psi "

$f_y = 60$ ksi, $\rho_{min} = \frac{200}{60{,}000} = 0.0033$

Use $\rho_{min} = 0.005$
$\rho_{max} = 0.75(0.0285) = 0.0214$

$\ell_d = \frac{0.04 A_b (60{,}000)}{\sqrt{4{,}000}} = 38 A_b$ (bott. bars)

Net factored soil pressure =
$q_n = 245.5 \div (9.25)^2 = 2.87$ ksf

Use Fig. 23.2: $a/B = 1/9.25 = 0.11$; $q_n/v_c = 2{,}870/215 = 13.3$
Min. $d = 0.105\,(111) = 11.7''$ Use $d = 12''$, $t = 12'' + 4'' = 1'\text{-}4''$

Check shear at de: $V_u = 2.87\left(\frac{9.25 + 2.0}{2} \times 3.63\right) = 58.6^K$

$v_u = \frac{58{,}600}{0.85(24)(12)} = 239$ psi ok < 253 psi

Steel required at ab: $M_u = 2.87(9.25)\frac{(4.125)^2}{2} = 226'^K = 2712''^K$

Use arm $= \pm 11.0''$ $T = 2712/11.0 = 247^K$
($d = \pm 2.0''$) $\div (0.90)(60) = 4.57$ sq. in.

$\rho_{min.} = 0.005\,(111)\,(12) = 6.66$ sq. in $= A_s > 4.56$ sq. in.

Use 11-#7 @ 10½" cts both ways, $A_s = 6.60$ sq. in.
Say ok

See Sh. 2 for check of compressive stress block and development length.

The piles commonly project 3 or 4 in. into the footing as shown in Fig. 23.3, and about 3 in. of concrete should separate the bottom reinforcement and the tops of the piles.

In general, the procedure for designing footings supported by piles closely parallels that used for footings on soil. Any differences are due to the concentrated reactions from the piles instead of the relatively uniform pressure from the soil. Although the locations of the piles in the field are likely to be at least several inches from their theoretical positions, it is common practice to take the critical section for shear at the same location as for footings on soil. As shown in Fig. 23.3, a section *de*, located at a distance equal to one half the depth of the footing from the face of the column, is ordinarily used for investigating diagonal tension. The critical section *ab* for flexure and development length may be assumed at the face of the column as in the case of footings on soil.

If the center of a pile is one half-diameter or more outside the critical section, the

DP 23-1
Building Footings
Sh. 2 of 2

Footing Design. Structural

Interior: Cont'd from Sh. 1

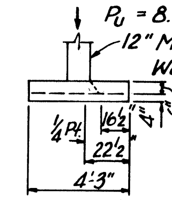
Check compressive stress block at ab:
$C = T = 247^K$
$\div 3.4 = 72.6$ sq. in.
$\div 111'' = 0.65'' < 2.0''$ ok

Arm $= 12 - \frac{0.65}{2} = 11.67'' > 11.0''$ but since $\rho_{min.}$ controls A_s, no reduction in A_s is possible

Check development length:
$\ell_d = 38 A_b = 38(0.60) = 22.8''$ ok $< 4'\text{-}0''$

Wall: (See DP 18-1 Shs. 1 & 2)

$P_u = 8.7^K/\text{ft.} = 1.4(3.8) + 1.7(2.0)$



Net factored Soil pressure =
$q_n = 8.7/4.25 = 2.05$ ksf

Depth required for shear
$V_u = 2.05(1.38) = 2.83^K/\text{ft.}$ of wall

$v_u = 2\sqrt{4{,}000}\,(0.85) = 108$ psi $d = \frac{2{,}830}{108(12)} = 2.18''$

Use Min. $d = 6''$, $t = 6'' + 4'' = 10''$

Steel required at ¼ Pt. of wall:

$M_u = 2.05\frac{(1.88)^2}{2} = 3.62'^K = 43.5''^K$

Say arm $= 5.0''$ $T = 43.5/5.0 = 8.70^K$
$\div (60 \times 0.9) = 0.16$ sq. in./ft.

$\rho_{min.} = 0.005 \times 12 \times 5 = 0.30$ sq. in./ft. $= A_s$

Use #5 @ 12" ctrs. $A_s = 0.31$

Longitudinal steel

Say $0.0025 \times 51 \times 6 = 0.76$ sq. in.

Use 4-#4 @ abt. 16" ctrs. $A_s = 0.80$

Compressive stress and development ok by inspection

entire reaction of the pile should be assumed effective in producing moment or shear on the section. The reaction from any pile located one half-diameter or more inside the section probably contributes very little to the moment or shear; hence, it may be considered as zero. For intermediate positions, a straight-line interpolation is commonly used to estimate the appropriate portion of pile reaction for analysis and design. By reference to Fig. 23.3, it becomes apparent that the shear and moment on *ab* will be produced by two full pile reactions, whereas the shear on *de* will be one pile reaction (two halves), provided the centers of the piles are more than half the pile diameter from the points *d* and *e*. For example, if the distance *x* is only one fourth of the pile diameter, three fourths of a pile reaction are assumed to contribute to the shear on section *de*.