

Structural Design Calculations Spread Footing for Temporary Bridge

Edwin R. Schmeckpeper, P.E.
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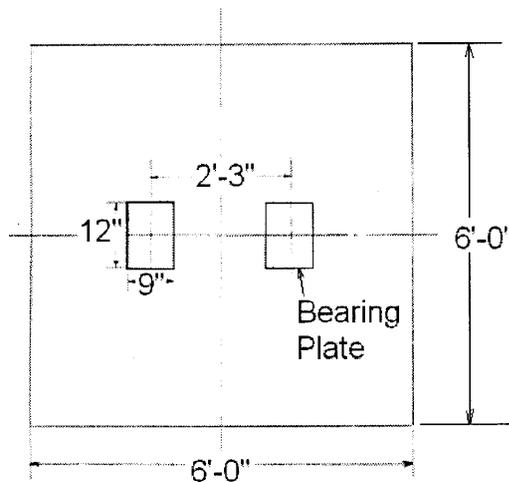
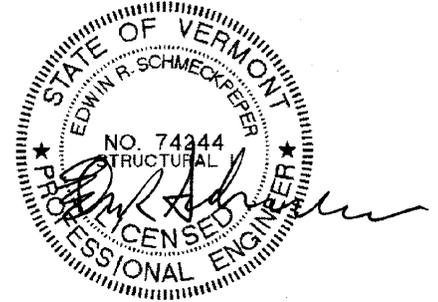


Figure 1: Plan View of Footing

General information (provided by J.B. Stevens.)

The footing is 6' x 6' x 18" thick. There are two bearing plates, 9" x 12" as show in the drawing. The 12" dimension is in the direction of traffic. The top of the footing is at grade.

The presumptive allowable net bearing capacity is 3000 psf.

Concrete strength $f_c=3500$ psi, Steel Reinforcing strength $f_y=60,000$ psi
Reinforcement is No. 6 bars spaced 6 inches each way.

The reinforcement has 3" cover to the bottom of the concrete 3" cover to the sides of the concrete, and 2" cover to the top of the concrete.

Design Loads:

Each pad has an unfactored dead load of 19 kips and unfactored live load of 35 kips.

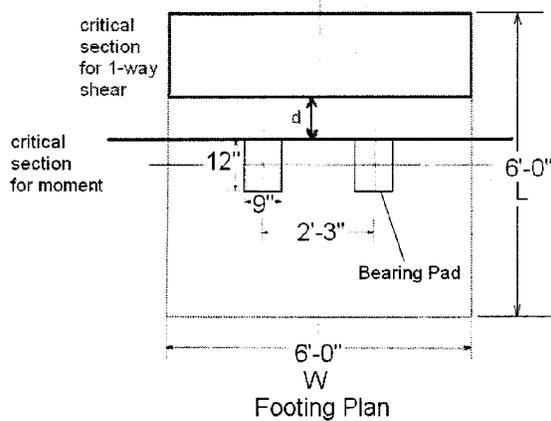
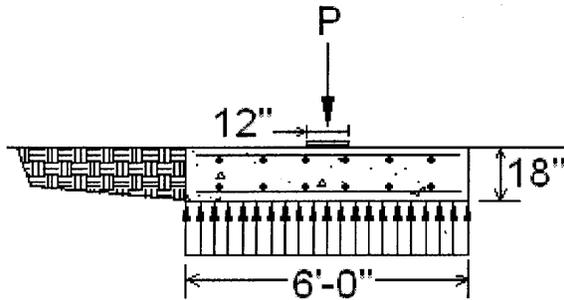
Applicable Codes and Standards

- AASHTO LRFD Bridge Design Specifications, 5th Edition, 2010
- ACI318-11 Building Code Requirements for Structural Concrete

Design Loads per Pad(unfactored) $P_D := 19 \cdot \text{kip}$ $P_L := 35 \cdot \text{kip}$

Load magnification factors from
AASHTO LRFD Bridge Design
Specifications $IM := 0.33$

Factored Loads per pad $P_u := 1.25 \cdot P_D + 1.75 \cdot (1 + IM) \cdot P_L$ $P_u = 105.2 \cdot \text{kip}$



$\gamma_{\text{conc}} := 0.15 \cdot \frac{\text{kip}}{\text{ft}^3}$ density of concrete footing

Factored pressure at base of footing

$$q_u := \frac{2P_u}{A_{\text{footing}}} + 1.25 \cdot \gamma_{\text{conc}} \cdot h = 6.126 \cdot \text{ksf}$$

Moment midway between face and center of bearing pad
(allow for flexibility of steel pad and for placement tolerances)

$$M_u := q_u \cdot W \cdot \left(\frac{L}{2} - \frac{b_{\text{pad}}}{4} \right)^2 \quad M_u = 278 \cdot \text{kip} \cdot \text{ft} < \quad \Phi M_n := \Phi_{\text{flexure}} \cdot A_s \cdot F_y \cdot \left(d - \frac{a}{2} \right) \quad \Phi M_n = 287 \cdot \text{kip} \cdot \text{ft}$$

Moment capacity is OK

Shear Strength: 1-way (Beam Action)

Critical section is d from midway between face and center of bearing pad $\Phi_{\text{shear}} := 0.90$ ACI 318-11 15.5

$$V_n := 2 \cdot \sqrt{f_c} \cdot \text{psi} \cdot W \cdot d \quad V_n = 118 \cdot \text{kip} \quad \Phi V_n := \Phi_{\text{shear}} \cdot V_n$$

$$V_u := q_u \cdot W \cdot \left[\left(\frac{L}{2} \right) - \left(\frac{b_{\text{pad}}}{2} \right) - d \right] \quad V_u = 59 \cdot \text{kip} < \quad \Phi V_n = 106 \cdot \text{kip} \quad \text{OK}$$

Square Footing $f_c := 3500 \cdot \text{psi}$ $F_y := 60000 \cdot \text{psi}$

$W := 6 \cdot \text{ft}$ $L := 6 \cdot \text{ft}$ $A_{\text{footing}} := W \cdot L = 36 \cdot \text{ft}^2$

$w_{\text{pad}} := 9 \cdot \text{in}$ $b_{\text{pad}} := 12 \cdot \text{in}$

$$q_a := \frac{2(P_D + P_L)}{W \cdot L} = 3.0 \cdot \text{ksf} \quad \text{OK}$$

$h := 18 \cdot \text{in}$ $\text{BottomCover} := 3 \cdot \text{in}$

$\text{SideCover} := 3 \cdot \text{in}$

$\text{BarSize} := 6$ $\text{NoBars} := 11$ (at 6" spacing, each way)

$$d_{\text{bar}} = 0.75 \cdot \text{in} \quad A_{\text{bar}} = 0.44 \cdot \text{in}^2$$

$$A_s := \text{NoBars} \cdot A_{\text{bar}} = 4.84 \cdot \text{in}^2$$

Determine moment capacity of footing

$$d := h - \text{BottomCover} - d_{\text{bar}} - \frac{d_{\text{bar}}}{2} \quad d = 13.875 \cdot \text{in}$$

$$a := \frac{A_s \cdot F_y}{0.85 \cdot f_c \cdot W} \quad a = 1.356 \cdot \text{in}$$

$$\rho := \frac{A_s}{W \cdot d} = 0.0048 > \rho_{\text{min}} := 0.0018 \quad \text{ACI 15.10.4}$$

$$\Phi_{\text{flexure}} = 0.90$$

Shear Strength: Two-Way (Punching)
Critical section is at $d/2$ from midway
between face and edge of bearing pad

ACI 318-11 15.5

For a shear around a single pad

$$\beta_{1_Pad} := \frac{\frac{12}{2} \cdot \text{in}}{\frac{9}{2} \cdot \text{in}} = 1.333$$

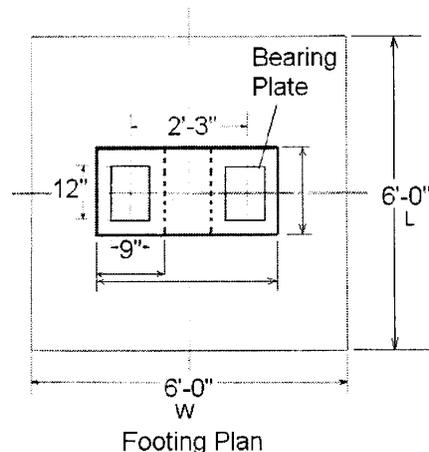
$$V_{u_1Pad} := q_u \cdot \left[\frac{W}{2} \cdot L - \left(\frac{12}{2} \cdot \text{in} + d \right) \cdot \left(\frac{9}{2} \cdot \text{in} + d \right) \right]$$

$$V_{u_1Pad} = 94.7 \cdot \text{kip}$$

$$b_{o_1Pad} := 2 \cdot \left(\frac{12}{2} \cdot \text{in} + d \right) + 2 \cdot \left(\frac{9}{2} \cdot \text{in} + d \right) = 76.5 \cdot \text{in}$$

$$\phi V_{n_1Pad} := \phi_{\text{shear}} \cdot \min \left(4, 2 + \frac{4}{\beta_{1_Pad}} \right) \cdot \left(\sqrt{f'_c} \cdot \text{psi} \cdot b_{o_1Pad} \cdot d \right)$$

$$V_{u_1Pad} = 94.7 \cdot \text{kip} < \phi V_{n_1Pad} = 226 \cdot \text{kip} \quad \text{OK}$$



For shear around both pads

$$\beta_{2_Pad} := \frac{31.5 \cdot \text{in}}{\frac{12}{2} \cdot \text{in}} = 5.25$$

$$V_{u_2Pad} := q_u \cdot [W \cdot L - (12 \cdot \text{in} + d) \cdot (36 \cdot \text{in} + d)]$$

$$V_{u_2Pad} = 165.6 \cdot \text{kip}$$

$$b_{o_2Pad} := 2 \cdot \left(\frac{12}{2} \cdot \text{in} + d \right) + 2 \cdot (36 \cdot \text{in} + d) = 139.5 \cdot \text{in}$$

$$\phi V_{n_2Pad} := \phi_{\text{shear}} \cdot \min \left(4, 2 + \frac{4}{\beta_{2_Pad}} \right) \cdot \left(\sqrt{f'_c} \cdot \text{psi} \cdot b_{o_2Pad} \cdot d \right)$$

$$V_{u_2Pad} = 165.6 \cdot \text{kip} < \phi V_{n_2Pad} = 285 \cdot \text{kip} \quad \text{OK}$$

Bearing on Pads $\phi_{\text{bearing}} := 0.65$
(ACI 10.14)

$$\Phi P_{n_bearing} := \phi_{\text{bearing}} \cdot (0.85 \cdot f'_c) \cdot 9 \cdot \text{in} \cdot 12 \cdot \text{in} \quad \Phi P_{n_bearing} = 209 \cdot \text{kip}$$

$$F_{\text{actored load per pad}} \quad P_u = 105 \cdot \text{kip} < \Phi P_{n_bearing} = 209 \cdot \text{kip} \quad \text{OK}$$

Development Length (ACI 12.2.3)

$$l_{d_available} := \frac{L}{2} - \frac{12 \cdot \text{in}}{2} - \text{SideCover}$$

$$l_d := \frac{3F_y}{40 \cdot \sqrt{f'_c} \cdot \text{psi} \cdot \left(\min \left(2.5, \frac{\text{BottomCover} + \frac{d_{\text{bar}}}{2}}{d_{\text{bar}}} \right) \right)} \cdot d_{\text{bar}}$$

$$l_d = 23 \cdot \text{in} < l_{d_available} = 27 \cdot \text{in} \quad \text{OK}$$