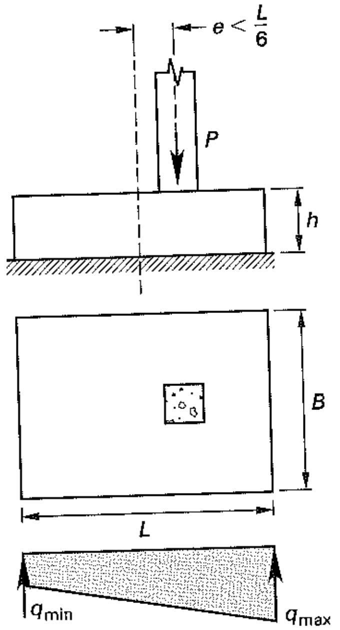
Figure 2.1 *Eccentricity Less than L/6*



The maximum and minimum values of the soil pressure are

$$q_{\text{max}} = \frac{P}{BL} + \frac{M}{S}$$

$$q_{\text{min}} = \frac{P}{BL} - \frac{M}{S}$$

For a rectangular footing, the length of the short side is B and the length of the long side is L. The section modulus of the footing is

$$S = \frac{BL^2}{6}$$

The maximum and minimum values of the soil pressure are

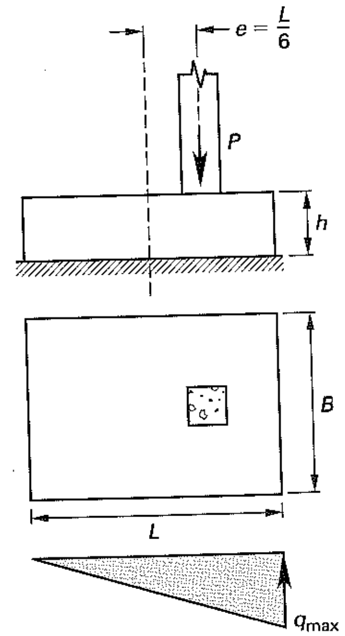
$$q_{\text{max}} = \left(\frac{P}{BL}\right)\left(1 + \frac{6e}{L}\right)$$

$$q_{\text{min}} = \left(\frac{P}{BL}\right)\left(1 - \frac{6e}{L}\right)$$

When the eccentricity of the column on the footing equals one-sixth of the longest side, $L/6$, as shown in Fig. 2.2, the resulting soil pressure distribution is triangular. The bending moment acting on the footing is

$$M = \frac{PL}{6}$$

Figure 2.2 *Eccentricity Equal to L/6*



The maximum and minimum values of the soil pressure are

$$q_{\text{max}} = \frac{P}{BL} + \left(\frac{PL}{6}\right)\left(\frac{6}{BL^2}\right)$$

$$= \frac{2P}{BL}$$

$$q_{\text{min}} = \frac{P}{BL} - \left(\frac{PL}{6}\right)\left(\frac{6}{BL^2}\right)$$

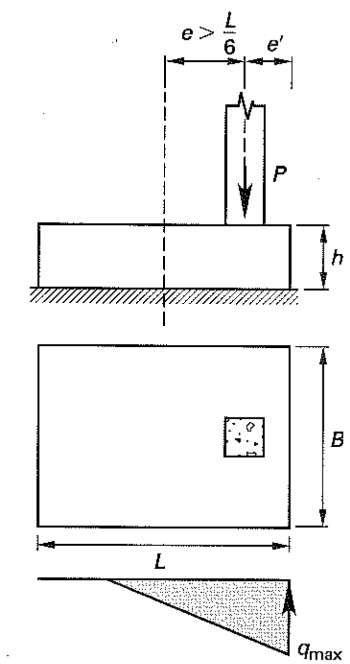
$$= 0$$

It is not possible to develop tensile stress at the interface of the soil and the soffit of the footing. Hence, when the eccentricity of the column on the footing exceeds one-sixth of the longest side, $L/6$, as shown in Fig. 2.3, the triangular soil pressure distribution extends over only a portion of the base. For equilibrium, the centroid of the pressure distribution must coincide with the line of action of the column axial service load, P. The length of the interface in compression is

$$x = 3e'$$

$$e' = \frac{L}{2} - e$$

Figure 2.3 *Eccentricity Greater than L/6*



Equating vertical forces gives

$$P = \frac{Bxq_{\text{max}}}{2}$$

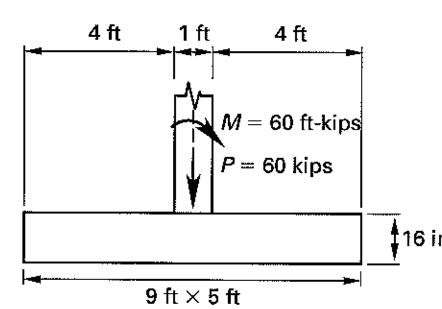
The maximum value of the soil pressure is

$$q_{\text{max}} = \frac{2P}{Bx}$$

$$= \frac{2P}{3Be'}$$

Example 2.1

The 9 ft × 5 ft reinforced concrete footing shown in the illustration supports a column with an axial load of P = 60 kips and a bending moment of M = 60 ft-kips. Determine the maximum pressure in the soil.



Solution

The weight of the footing is

$$W_b = w_c LBh$$

$$= \frac{\left(150\ \frac{\text{lbf}}{\text{ft}^3}\right)(9\ \text{ft})(5\ \text{ft})(16\ \text{in})}{\left(1000\ \frac{\text{lbf}}{\text{kip}}\right)\left(12\ \frac{\text{in}}{\text{ft}}\right)}$$

$$= 9\ \text{kips}$$

The total load on the soil is

$$P_T = P + W_b$$

$$= 60\ \text{kips} + 9\ \text{kips}$$

$$= 69\ \text{kips}$$

The equivalent eccentricity of the total load is

$$e = \frac{M}{P_t}$$

$$= \frac{60\ \text{ft-kips}}{69\ \text{kips}}$$

$$= 0.87\ \text{ft}$$

$$< L/6 \quad [\text{within middle third of the base}]$$

The maximum soil pressure is

$$q_{\text{max}} = \left(\frac{P_T}{BL}\right)\left(1 + \frac{6e}{L}\right)$$

$$= \left(\frac{69\ \text{kips}}{(5\ \text{ft})(9\ \text{ft})}\right)\left(1 + \frac{(6)(0.87\ \text{ft})}{9\ \text{ft}}\right)$$

$$= 2.4\ \text{kips/ft}^2$$

Factored Soil Pressure

A reinforced concrete footing must be designed for punching shear, flexural shear, and flexure. The critical section for each of these effects is located at a different position in the footing, and each must be designed for the applied factored loads. Hence, the soil pressure distribution caused by factored loads must be determined. Because the self-weight of the footing produces an equal and opposite pressure in the soil, the footing is designed for the net pressure from the column load only, and the weight of the footing is not included.

Example 2.2

The 9 ft × 5 ft reinforced concrete footing described in Ex. 2.1 supports a column with a factored axial load of P_u = 100 kips. It has a factored bending moment

Foundations