

From ACI Sec. 16.5.3.5, the horizontal tensile force caused by volume changes is

$$N_{uc} \geq 0.2V_u$$

The bending moment caused by the applied shear force and the horizontal tensile force is

$$M_u = V_u a_v + N_{uc}(h - d)$$

The required area of shear friction reinforcement provided by the primary steel and horizontal closed stirrups is given by ACI Sec. 22.9.4.2 as

$$A_{vf} = \frac{V_u}{\phi f_y \mu}$$

ACI Table 22.9.4.2 gives the value of the coefficient of friction at the face of the support as $\mu = 1.4\lambda$ for concrete placed monolithically, and defines the correction factor related to the unit weight of concrete as $\lambda = 1.0$ for normal weight concrete. ACI Table 21.2.1 gives the value of the strength reduction factor as $\phi = 0.75$ for all design calculations.

The required area of reinforcement to resist N_{uc} is given by ACI Sec. 16.5.4.3 as

$$A_n = \frac{N_{uc}}{\phi f_y}$$

The required area of flexural reinforcement, A_f , to resist the moment M_u is derived by the normal flexural theory given by ACI Sec. 22.2, using a strength reduction factor of $\phi = 0.75$ as specified by ACI Table 21.2.1.

The required total area of primary tension reinforcement is given by ACI Sec. 16.5.5.1 as the greater of

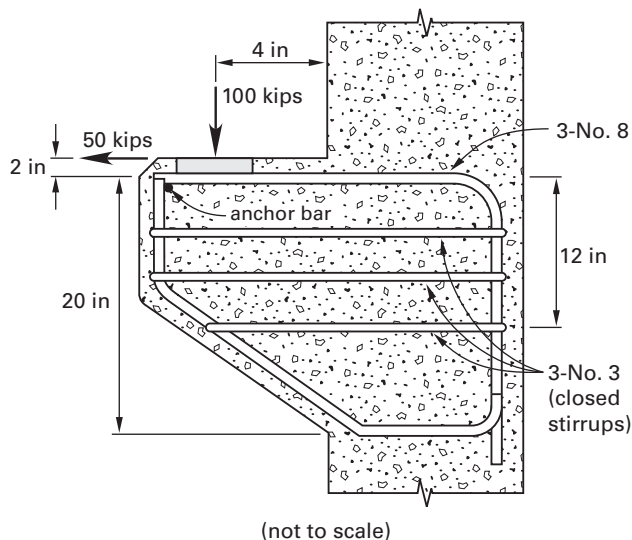
$$\begin{aligned} A_{sc} &= A_f + A_n \\ &= \frac{2A_{vf}}{3} + A_n \\ &= \frac{0.04b_w d f'_c}{f_y} \end{aligned}$$

The minimum required area of closed ties, distributed over a depth of two-thirds of the effective depth, is given by ACI Sec. 16.5.5.2 as

$$A_h = \frac{A_{sc} - A_n}{2}$$

Example 1.2

The reinforced concrete corbel shown in the illustration, with a width of 15 in, is reinforced with grade 60 bars and has a concrete compressive strength of 3000 lbf/in². Determine whether the corbel is adequate for the applied factored loads indicated.



Solution

$$\begin{aligned} 0.2\phi f'_c b_w d &= (0.2)(0.75) \left(3 \frac{\text{kips}}{\text{in}^2} \right) (15 \text{ in})(20 \text{ in}) \\ &= 135 \text{ kips} \\ &> V_u \quad [\text{satisfies ACI Table 22.9.4.4}] \end{aligned}$$

The other requirements of ACI Table 22.9.4.4 are also satisfied.

The shear friction reinforcement area is given by ACI Sec. 22.9.4.2 as

$$\begin{aligned} A_{vf} &= \frac{V_u}{\phi f_y \mu} = \frac{100 \text{ kips}}{(0.75) \left(60 \frac{\text{kips}}{\text{in}^2} \right) (1.4)} \\ &= 1.59 \text{ in}^2 \end{aligned}$$

The tension reinforcement area is given by ACI Sec. 16.5.4.3 as

$$\begin{aligned} A_n &= \frac{N_{uc}}{\phi f_y} \\ &= \frac{50 \text{ kips}}{(0.75) \left(60 \frac{\text{kips}}{\text{in}^2} \right)} \\ &= 1.111 \text{ in}^2 \end{aligned}$$