Shear in Brackets, & Corbels

Design of Brackets and Corbels

Givens: 1)$V_{u(shear)}$, 2) Column Size, 3) f_c' , 4) concrete weight, $f_{y(rebar)}$, $\emptyset = 0.75$

ACI 11.8 Provisions for Brackets and Corbels Ø=0.75 for all calculations

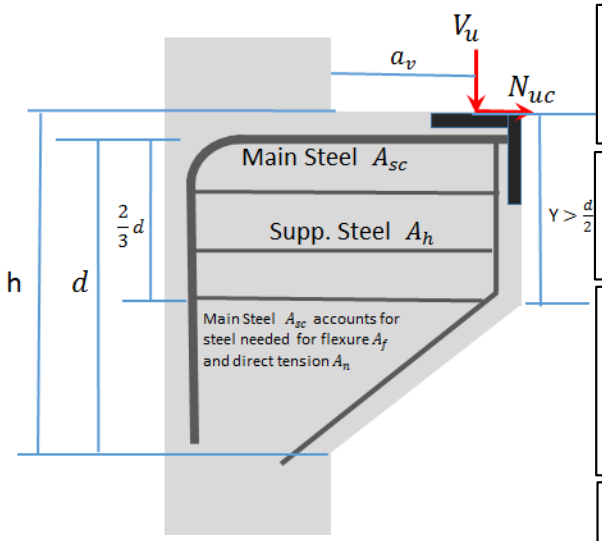
- Brackets and corbels with an a_v/d ratio less than 2 shall be permitted to use design methods from ACI 318 Appendix A (**Strut-and-Tie Model**).
- Brackets and corbels may be designed w/ ACI 318 11.8.3 & 11.8.4 when:
  - $a_v/d \leq 1$
  - Horizontal tensile force (N_{uc}) not larger than V_u , but N_{uc} must be greater than $0.2V_u$
  - Depth at outside edge of bearing area shall be $\geq 0.5d$
  - Yield strength of reinforcement $\leq 60ksi$
  - Main steel (A_{sc}) must develop at face of support. Commonly requires anchorage to cross-bar or metal plate at face of corbel.
  - Shear transfer occurs through shear friction
  - Supplementary shear friction steel (closed ties) may be distributed over top 2/3 of member

Selection of Bearing Plate

1) Compute distance a_v between V_u and column face.
2) Assume bearing plate length for available column size.
   For 16" col. try 12"(into the page) wide bearing plate
3) ACI 318 Section 10.14 (allowable bearing stress)
   $\emptyset_{bearing}(0.85f_c')$ where: $\emptyset_{bearing} = 0.65$
   Required length (along beam bottom) = $\frac{V_u}{[\emptyset_{bearing}(0.85f_c')][Assumed\ Length]}$
   Upsize as needed

Determine Corbel Size (USE ACI 11.8.3.2.1 or ACI 11.8.3.2.2 Provisions)

1) For Nrml wt conc Min. $d_{min} = \frac{V_u}{smallest\ of \begin{cases}(\emptyset_{Shear})0.2f_c'b_w \\ (\emptyset_{Shear})(480+0.08f_c')b_w \quad (Typically\ Governs) \\ (\emptyset_{Shear})1600b_w\end{cases}}$
2) Upsize d_{min} as needed ➔ choose reasonable "h" ➔ $d = h - (1.5" + \frac{d_b}{2})$
3) Corbel base width = same as column to aid construction.



Compute Forces on Corbel: ACI 11.8.3.4

$N_{uc} = larger\ of \begin{cases}1.6\ (N_{service}) < V_u \\ 0.2V_u\end{cases}$

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

Compute Shear Friction Steel (A_{vf}): ACI 11.6.4.1

$\emptyset V_n \geq V_u$ ➔ $A_{vf} = \frac{V_n}{\mu f_y} = \frac{V_u}{\emptyset \mu f_y}$

Modify μ by concrete type on previous slide.

Compute Flexural Reinf (A_f): ACI 11.8.3.3

Iterative: $M_u \leq \emptyset A_f f_y \left(d - \frac{a}{2}\right)$ Assuming$\left(d - \frac{a}{2}\right) \approx 0.9$d

$A_{f(first)} \geq \frac{M_u}{\emptyset_{Shear} f_y 0.9d} = \#in^2$ ➔ $a = \frac{A_f f_y}{0.85 f_c' b}$

$A_{f(true)} \geq \frac{M_u}{\emptyset_{Shear} f_y \left(d - \frac{a}{2}\right)}$

Compute Direct Tension Steel: ACI 11.8.3.4

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

Compute Area of Tension-Tie Reinf: ACI 11.8.3.5

$A_{sc} \geq larger\ of \begin{cases}A_f + A_n \\ \frac{2}{3}A_{vf} + A_n\end{cases}$ Check vs ACI 11.8.5 $A_{sc(MIN)} = \frac{0.04 f_c'}{f_y} b_w d$

SELECT MAIN STEEL BARS BY A_{sc}

Compute Area of Horizontal Stirrups: ACI 11.8.4

$A_h = \frac{A_{sc} - A_n}{2}$ SELECT HORZ. STIRRUP BARS BY A_{sc} ➔TOP 2/3 OF "d" DIM.

Establish Anchorage of Tension-Tie into Column: ACI 12.5.1 90^o hooks w/ bars selected for A_{sc}. $l_{dh} = \left(\frac{0.02\Psi_e f_y}{\lambda\sqrt{f_c'}}\right) d_b$

Measured from face of column. So ACI 12.5.3a reduction factor applies (0.7 here).

Establish Anchorage of Outer Bar Ends: Develop $A_{sc} f_y$ by welding to angle or an embedded bar (int/out-of the page at the nose of the Corbel).

Other Details: ACI 11.8.2 & 11.8.7
Use a pair of #3 or 4 bars to anchor the front of the Supp. Steel stirrups.