Ledge Shear Capacity

Description Calculation of ledge concrete shear capacity

References PCI Design Handbook 8th Edition

Concrete Geometry and Material Properties

Height of the member $h_{pre} := 84\ in$

Width of the stem $w_{stem} := 10\ in$

Height of the ledge $w_{ledge} := 8\ in$

Width of the ledge $h_{ledge} := 9.5\ in$

Area of spandrel $A_g := h_{pre} \cdot w_{stem} + w_{ledge} \cdot h_{ledge}$

$A_g = 916\ in^2$

Concrete compressive strength $f_c := 6.5\ ksi$

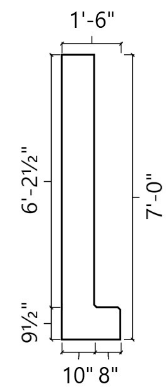

Figure 1: Concrete Geometry of Spandrel

Prestress Properties

Jacking ratio $Jacking := 75\ \%$

Ultimate stress $f_{pu} := 270\ ksi$

Area of prestress $A_{ps} := 11 \cdot 0.167\ in^2 = 1.837\ in^2$

Area of prestress at end $A_{ps.end} := 0.33\ in^2$

Losses at end location $Losses_{end} := 5.72\ \%$

Losses at midspan $Losses_{midspan} := 7.05\ \%$

Calculated Demands and Capacities

Ultimate moment at end location $M_{u.end} := 4.64\ kip\ ft$

Nominal capacity at end location $M_{n.end} := \frac{306.24}{0.6}\ kip\ ft = 510.4\ kip\ ft$

Ultimate shear at end location $V_{u.end} := 155.6\ kip$

Nominal capacity at end location $V_{n.end} := \frac{222.8}{0.75}\ kip = 297.0667\ kip$

Ultimate moment at midspan $M_{u.midspan} := 1882.35\ kip\ ft$

Nominal capacity at midspan $M_{n.midspan} := \frac{2037.98}{0.9}\ kip\ ft = 2264.4222\ kip\ ft$

Ultimate shear at midspan $V_{u.midspan} := 0\ kip$

Nominal capacity at midspan $V_{n.midspan} := \frac{139.1}{0.75}\ kip = 185.4667\ kip$

Ledge Parameters

Resistance factor $\varphi := 0.75$

Lightweight concrete factor $\lambda := 1.0$

Bearing width on ledge $b_t := 4\ in$

Height of the ledge $h_l := h_{ledge} = 9.5\ in$

Spacing of the loads $s := 6\ ft$

Projection of ledge $l_p := w_{ledge} = 8\ in$

Midspan Ledge Capacity

Internal prestress force $P_i := Jacking \cdot A_{ps} \cdot f_{pu} \cdot \left(1 - Losses_{midspan}\right) = 345.767\ kip$

Stress due to prestress $f_{pc} := \dfrac{P_i}{A_g} = 377.4749\ psi$

Coefficient for the effect of prestress $\gamma := \sqrt{1 + 10 \cdot \dfrac{f_{pc}}{f_c}} = 1.2573$

Maximum ratio of demand to capacity $R := \max\left(\left[\dfrac{V_{u.midspan}}{V_{n.midspan}} \quad \dfrac{M_{u.midspan}}{M_{n.midspan}}\right]\right) = 0.8313$

Coefficient of shear strength

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β := if  R ≥ 0.6          = 1
       1
     else
       if  R ≤ 0.2
         2
       else
         1 + 2.5·(0.6 − R)
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Figure 5.6.2

Shear strength of the ledge $\varphi V_{n.a} := \varphi \cdot \lambda \cdot \gamma \cdot \beta \cdot \sqrt{\dfrac{f_c}{psi}}\ psi \cdot h_l \cdot \left(b_t + 2 \cdot h_l + 2 \cdot l_p\right) = 28.1666\ kip$ Equation 5-76

$\varphi V_{n.b} := \varphi \cdot 0.5 \cdot \lambda \cdot \gamma \cdot \beta \cdot \sqrt{\dfrac{f_c}{psi}}\ psi \cdot h_l \cdot \left(b_t + 2 \cdot h_l + s + 2 \cdot l_p\right) = 40.0833\ kip$ Equation 5-77

$\phi V_{n.midspan} := \min\left(\left[\varphi V_{n.a} \quad \varphi V_{n.b}\right]\right) = 28.1666\ kip$

End Ledge Capacity

Distance from edge to load $d_e := 5.91\ in$

Limit before failure plane changes $limit := 0.5 \cdot b_t + h_l + l_p = 19.5\ in$

Since de is less than the limit, check asymmetric failure condition

Internal prestress force $P_i := Jacking \cdot A_{ps.end} \cdot f_{pu} \cdot \left(1 - Losses_{end}\right) = 63.0026\ kip$

Stress due to prestress $f_{pc} := \dfrac{P_i}{A_g} = 68.7801\ psi$

Coefficient for the effect of prestress $\gamma := \sqrt{1 + 10 \cdot \dfrac{f_{pc}}{f_c}} = 1.0516$

Maximum ratio of demand to capacity $R := \max\left(\left[\dfrac{V_{u.end}}{V_{n.end}} \quad \dfrac{M_{u.end}}{M_{n.end}}\right]\right) = 0.5238$

Coefficient of shear strength

$$\beta := \text{if } R \geq 0.6 \;\; 1 \;\; \text{else} \;\; \text{if } R \leq 0.2 \;\; 2 \;\; \text{else} \;\; 1 + 2.5 \cdot (0.6 - R) = 1.1905$$

Figure 5.6.2

Shear strength of the ledge

$$\varphi V_{n.a} := \varphi \cdot \lambda \cdot \gamma \cdot \beta \cdot \sqrt{\frac{f_c}{psi}}\, psi \cdot h_l \cdot \left(0.5 \cdot b_t + h_l + d_e + l_p\right) = 18.27\ kip$$

Equation 5-78

$$\varphi V_{n.b} := \varphi \cdot 0.5 \cdot \lambda \cdot \gamma \cdot \beta \cdot \sqrt{\frac{f_c}{psi}}\, psi \cdot h_l \cdot \left(0.5 \cdot b_t + h_l + d_e + s + l_p\right) = 35.0265\ kip$$

Equation 5-79

$$\phi V_{n.end} := \min\left(\left[\varphi V_{n.a} \;\; \varphi V_{n.b}\right]\right) = 18.2738\ kip$$