Masonry Strength Design

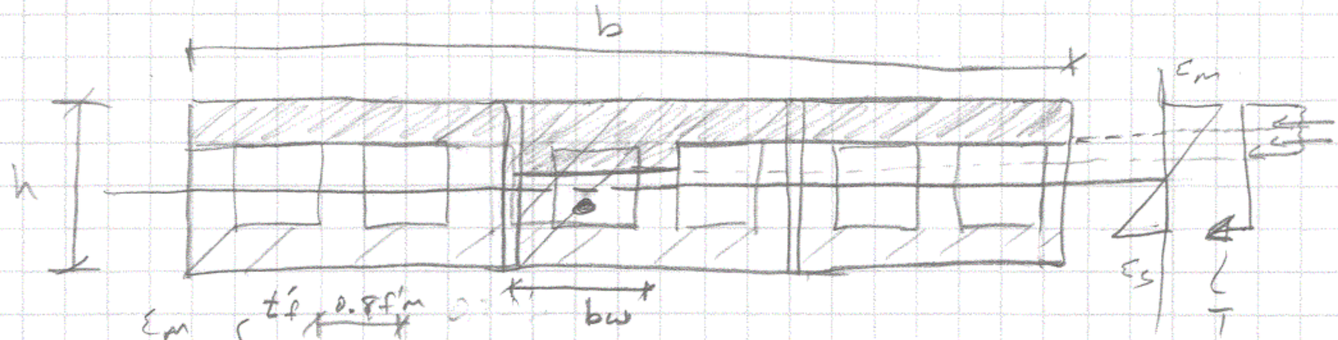
JOB: MASONRY – STR Design

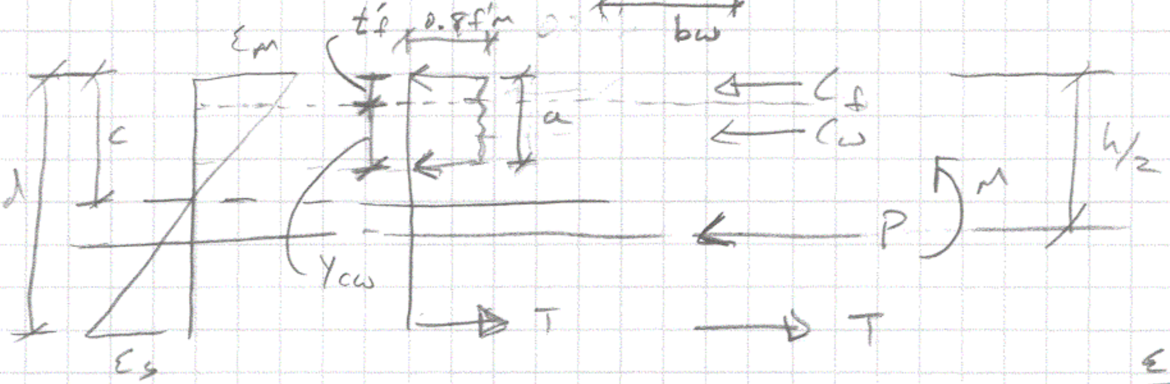
SHEET NO.: 1 OF

CALCULATED BY: DATE:

CHECKED BY: DATE:

SCALE: Out-of-Plane





$$\frac{\varepsilon_s}{d-c} = \frac{\varepsilon_m}{c}$$

$$t'_f = \min(t_f,\ a)$$

$$a = 0.8\,c$$

$$Y_{cw} = (0,\ a - t'_f)$$

$$\varepsilon_s = \frac{\varepsilon_m}{c} \times (d - c) \Rightarrow f_s = (\varepsilon_s E,\ F_y)$$

$$C_f = 0.8 f'_m \times t'_f \times b \qquad x_{cf} = h/2 - t'_f/2$$

$$C_w = 0.8 f'_m \times y_{cw} \times b_w \qquad x_{cw} = h/2 - (t'_f + y_{cw}/2)$$

$$T = f_s A_s \qquad X_{s1} = h/2 - d$$

$$\Sigma F = 0 \qquad P_n = C_f + C_w - T$$

$\Sigma M = 0$ @ $h/2$ $\qquad M_n = C_f X_{cf} + C_w X_{cw} + T X_{s1}$

$$e = \frac{M}{P}$$ (design eccentricity)

For out-of-plane loading $\Rightarrow \varepsilon_s > 1.5\,\varepsilon_y$

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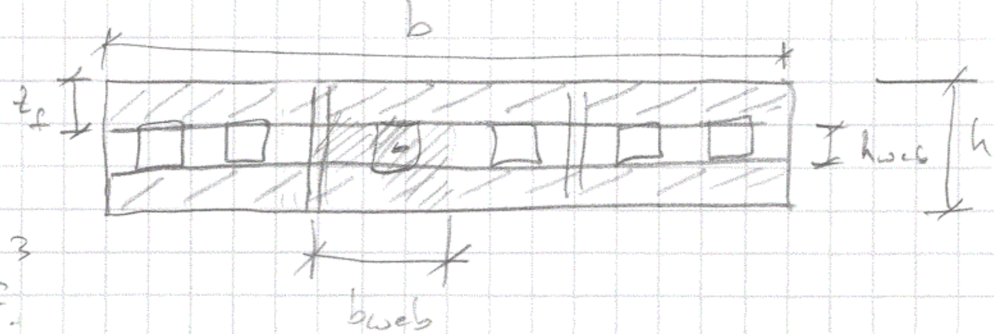
P-Δ Method

Properties



Gross

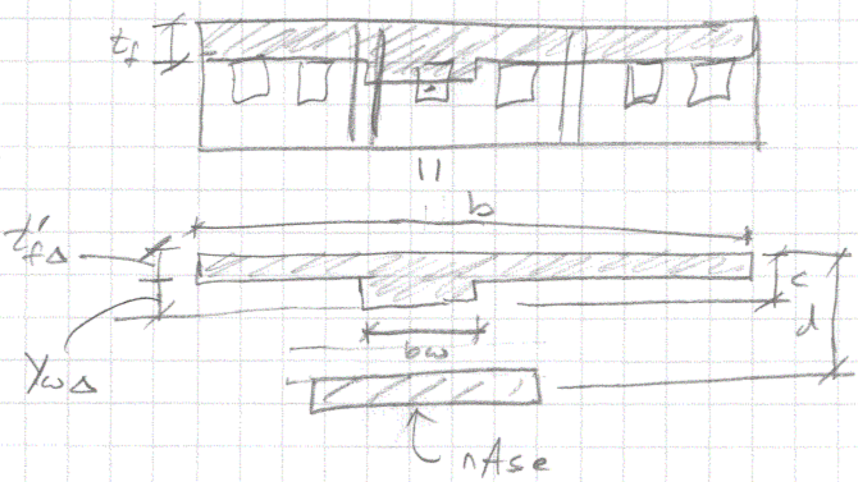
$$I_g = \frac{b_w h_{web}^3}{12} + \frac{b \times t_f^3}{12} + 2 \times \left[(b \times t_f) \times \left(\frac{h}{2} - \frac{t_f}{2}\right)^2\right]$$

$$M_{cr} = f_r \times \frac{2 I_g}{h}$$ (for f_r modulus of rupture see code MSJC Tbl 3.1.8.2.1)

Cracked

$t'_{f\Delta} = \min(t_f, c)$

$y_{w\Delta} = \min(0, c - t_f)$



$$I_{cr} = \frac{b_w \times y_{w\Delta}^3}{12} \times (y_{w\Delta} \times b_w)\left(\frac{y_{w\Delta}}{2}\right)^2 + \frac{b \times t'^3_{f\Delta}}{12} + (t'_{f\Delta} \times b)\left(c - \frac{t'_{f\Delta}}{2}\right)^2 + nA_{se} \times (d-c)^2$$

$$A_{se} = \frac{P_u + A_s f_y}{f_y}$$

Axial load help resist. Conservatively use ½ LL Full DL.

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Deflection for simple span

$$\delta = \frac{5 M_{cr} H^2}{48 E_m I_g} + \frac{5 (M_{ser} - M_{cr}) H^2}{48 E_m I_{cr}}$$

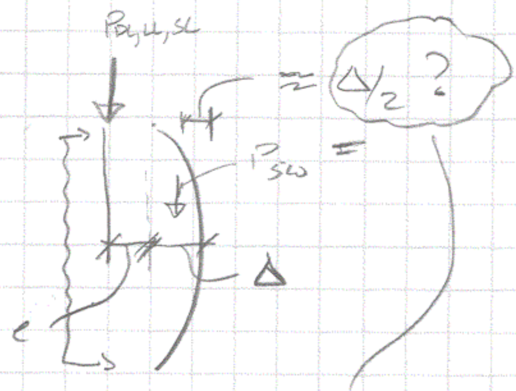
$$\text{Convergence} = \frac{\delta_i - \delta_{previous}}{\delta} \times 100 \leq 5\%$$

δ_{max} service loads $= 0.007H$

← Amplified moment

$$M_{ua} = M_{lat} + P_{sw} \times \frac{\Delta}{2} + P_{DL/SL/LL} \times \Delta + P_{DL/LL/SL}\, e$$

Moment due to lateral load. Self wt. @ mid Ht. eccentricity of load



Reinf. Masonry Handbook Fig 6.18 shows 2/3 Δ but uses 1/2 Δ

→ Iterate deflection until Convergence is < 5%

Then can find required eccentricity of section

$$e_r = \frac{M_{ua}}{P_u}$$

P_u ← Total req'd load

⟹ Compare this to design eccentricity. Iterate location of N.A. (c) until req'd = design eccentricity.

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Checks

Shear $\phi = 0.8$

$$\phi V_n = (V_m + V_s)\phi$$

$$V_n = \max \begin{cases} 6 A_n \sqrt{f'_m} & \frac{M}{Vd} \le 0.25 \\ 4 A_n \sqrt{f'_m} & \frac{M}{Vd} \ge 1.0 \end{cases} \quad \text{Interpolate}$$

$$V_m = \left[4 - 1.75\left(\frac{M}{Vd}\right)\right] A_n \sqrt{f'_m} + 0.25 P_u \qquad \left(\frac{M}{Vd} \; \text{Max} = 1.0\right)$$

$$V_s = 0.5 \times \left(\frac{A_v}{s}\right) f_y d_v$$

Axial & Moment $\phi_{AB} = 0.9$

$$F_a = \begin{cases} 0.2 f'_m & \frac{H}{h} \le 30 \\ 0.05 f'_m & H/h > 30 \end{cases}$$

$\phi_{AB} P_n > P_u$

$\phi_{AB} M_n > M_u$

Ductility = steel strain $\varepsilon_s > 1.5\,\varepsilon_y$