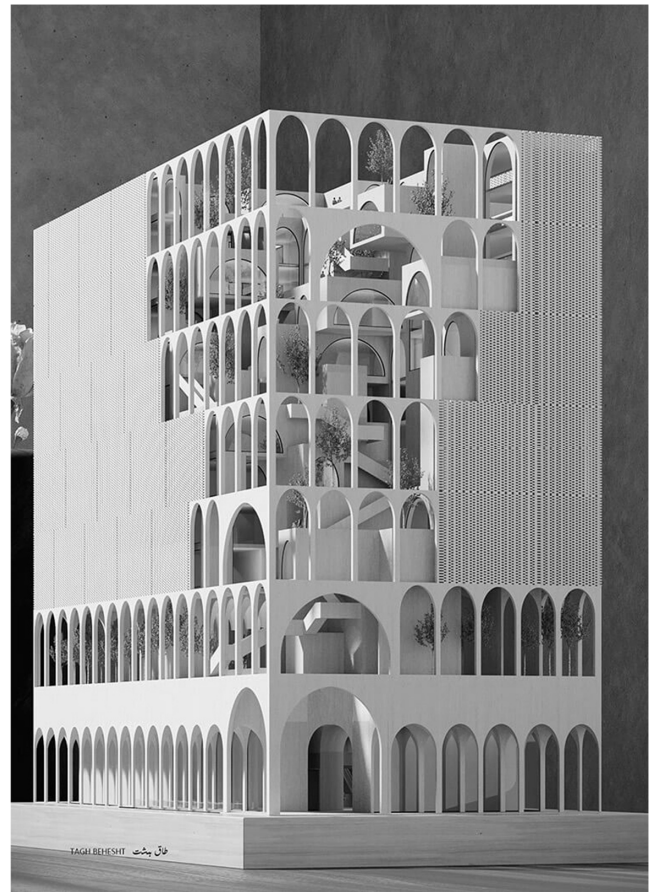


Combined Axial and Flexure Load

Part 2

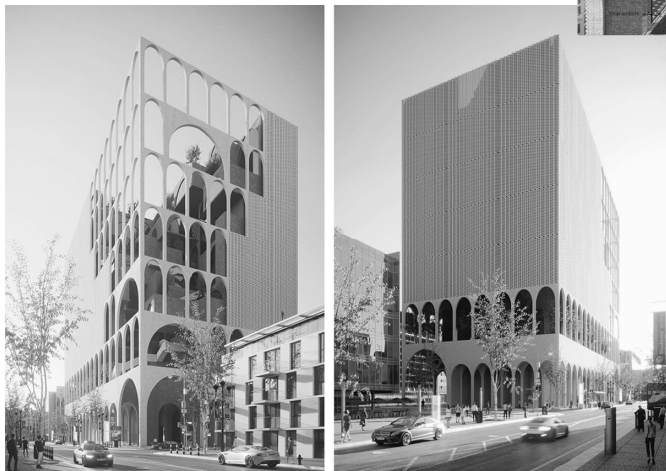
- Concentric axial
- Interaction
- Bearing walls

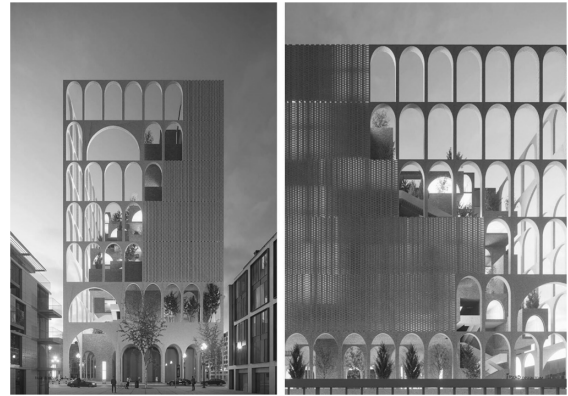
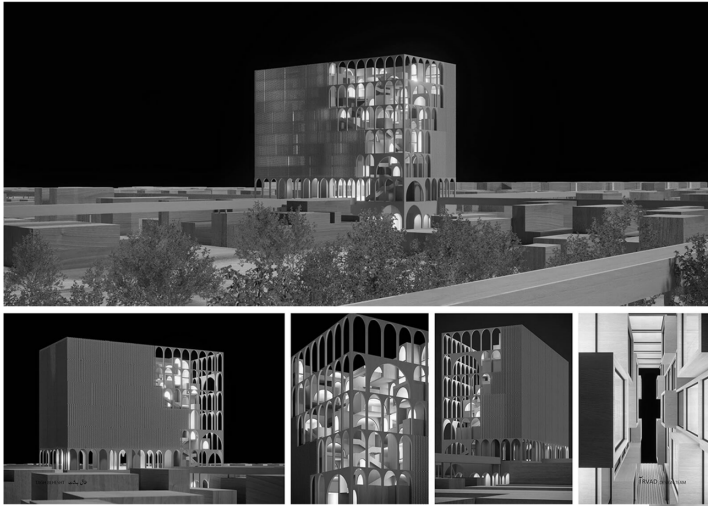


Tagh Behesht
by Rvad Studio

Tagh Behesht by Rvad Studio

The project's primary design methodology began with an investigation of architectural history of bazaars in Iran and the city of Mash-had. Since time immemorial, the unbreakable bond between the city bazaars and the foundations of the economy has led to bazaars taking on an important and consistent role in people's daily lives.





University of Michigan, TCAUP

Masonry

Slide 3 of 20

Combined Bending and Axial Load

CMU Pilaster Analysis

$h = 24 \text{ ft}$

o.c. spacing = 16 ft

$f'_m = 2000 \text{ psi}$

Gr 60 reinforcement , $f_y = 60 \text{ ksi}$

4 x#5 A_b / bar = 0.31 in^2

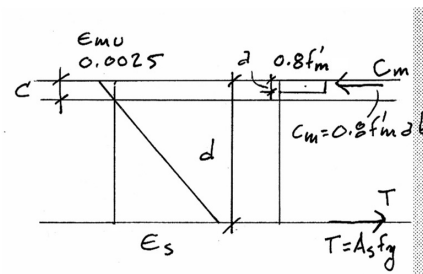
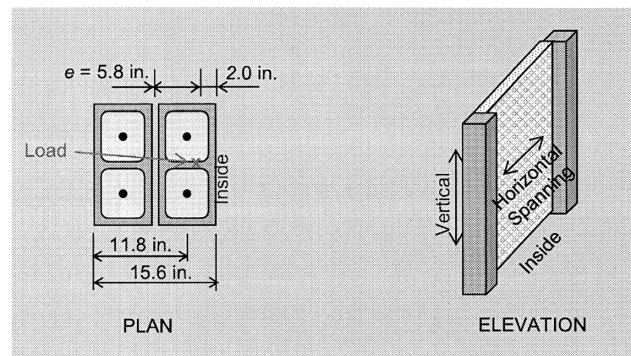
reinforcement not laterally tied

eccentricity = 5.8 in.

$D_{\text{roof}} = 9.6 \text{ k}$ $D_{\text{self}} = 200 \text{ plf}$ $W = 8.1 \text{ k (uplift)}$

$W = 26 \text{ psf (lateral suction on wall)}$

Load combination: $0.9 D + 1.0 W$



Find P_u :

Loads:

Check load combination $0.9D + 1.0W$ as it usually controls.

Pilaster weight (fully grouted): $75 \text{ psf}(1.33 \text{ ft})(2 \text{ wythes}) = 200 \text{ lb/ft}$

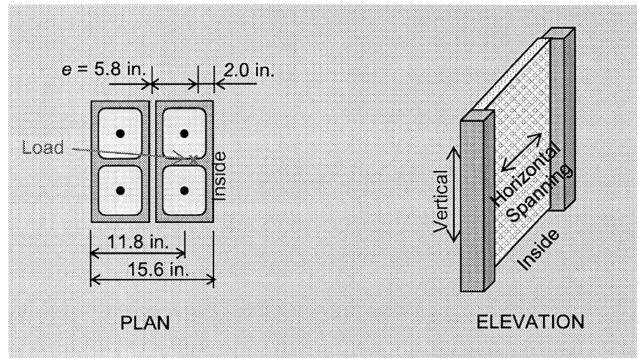
Axial load at top of pilaster, P_{uf} : $0.9(9,600 \text{ lb}) - 1.0(8,100 \text{ lb}) = 540 \text{ lb}$

Axial load at midheight: $P_u = P_{uf} + P_{u,pilaster} = 540 \text{ lb} + 0.9 (200 \text{ lb/ft})(12 \text{ ft}) = 2,700 \text{ lb}$

Combined Bending and Axial Load

CMU Pilaster Analysis

$h = 24 \text{ ft}$
 $\text{o.c. spacing} = 16 \text{ ft}$
 $f'_m = 2000 \text{ psi}$
 $\text{Gr 60 reinforcement, } f_y = 60 \text{ ksi}$
 $4 \times \#5 \quad A_b \text{ per bar} = 0.31 \text{ in}^2$
 $\text{reinforcement not laterally tied}$
 $\text{eccentricity} = 5.8 \text{ in.}$
 $D_{\text{roof}} = 9.6 \text{ k} \quad D_{\text{self}} = 200 \text{ plf} \quad W = 8.1 \text{ k (uplift)}$
 $W = 26 \text{ psf (lateral suction on wall)}$
 $\text{Load combination: } 0.9 D + 1.0 W$



$$A_s = 0.31 \text{ in}^2 \times 2 = 0.62 \text{ in}^2$$

$$P_u = 0.9(9600 \text{ lb}) - 1.0(8100 \text{ lb}) = 540 \text{ lb}$$

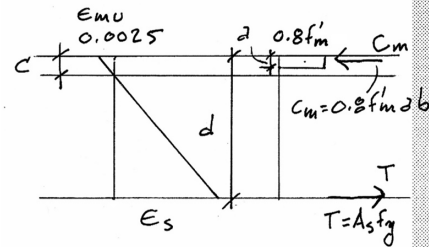
$$P_u = 540 \text{ lb} + 0.9(200 \text{ lb/ft})(12 \text{ ft}) = 2700 \text{ lb}$$

$$a = \frac{A_s f_y + P_u / \phi}{0.8 f'_m b} = \frac{0.62 \text{ in}^2 \times 60,000 \text{ psi} + 2700 \text{ lb} / 0.9}{0.8 \times 2000 \text{ psi} \times 15.6 \text{ in}} = 1.61 \text{ in}$$

$$c = \frac{a}{0.8} = \frac{1.61 \text{ in}}{0.8} = 2.01 \text{ in}$$

$$C_m = 0.8 f'_m a b = 0.8 \times 2000 \text{ psi} \times 1.61 \text{ in} \times 15.6 \text{ in} = 40,200 \text{ lb}$$

$$T = A_s f_y = 0.62 \text{ in}^2 \times 60,000 \text{ psi} = 37,200 \text{ lb}$$



$$M_{u0} = \frac{w_u h^2}{8} + \frac{P_u e_u}{2}$$

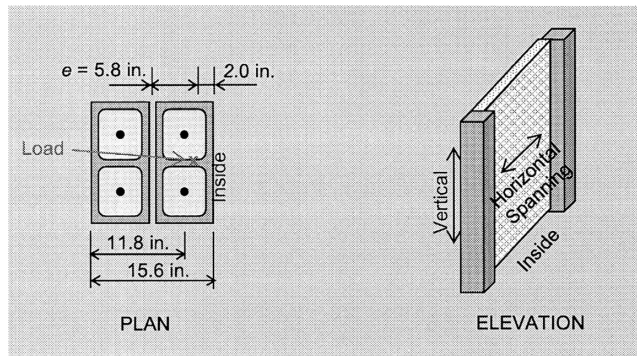
$$a = \frac{A_s f_y + P_u / \phi}{0.80 f'_m b}$$

$$\frac{416 \text{ lb/ft}(24 \text{ ft})^2}{8} + \frac{(540 \text{ lb})(5.8/12 \text{ ft})}{2} = 30,100 \text{ lb-ft}$$

Combined Bending and Axial Load

CMU Pilaster Analysis

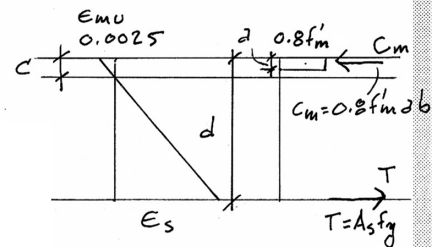
$h = 24 \text{ ft}$
 $\text{o.c. spacing} = 16 \text{ ft}$
 $f'_m = 2000 \text{ psi}$
 $\text{Gr 60 reinforcement, } f_y = 60 \text{ ksi}$
 $4 \times \#5 \quad A_b \text{ per bar} = 0.31 \text{ in}^2$
 $\text{reinforcement not laterally tied}$
 $\text{eccentricity} = 5.8 \text{ in.}$
 $D_{\text{roof}} = 9.6 \text{ k} \quad D_{\text{self}} = 200 \text{ plf} \quad W = 8.1 \text{ k (uplift)}$
 $W = 26 \text{ psf (lateral suction on wall)}$
 $\text{Load combination: } 0.9 D + 1.0 W$



$$\phi P_n = \phi (C_m - T) = 0.9(40,200 \text{ lb} - 37,200 \text{ lb}) = 2700 \text{ lb}$$

$$\phi M_n = \phi (P_u / \phi + A_s f_y) \left(d - \frac{a}{2} \right) = 0.9 \left(\frac{2700 \text{ lb}}{0.9} + 0.62 \text{ in}^2 \times 60,000 \text{ psi} \right) \left(11.8 \text{ in} - \frac{1.61 \text{ in}}{2} \right)$$

$$\phi M_n = 398,000 \text{ lb-in}$$



$$P_{\text{max}} = 0.64 f'_m \left(\frac{E_{mu}}{E_{mu} + 1.5 E_y} \right) - \frac{P}{b d} = \frac{0.64 \times 2000 \text{ psi} \left(\frac{0.0025}{0.0025 + 1.5 \times 0.000047} \right) - \frac{1500 \text{ lb}}{15.6 \text{ in} \times 11.8 \text{ in}}}{60,000 \text{ psi}}$$

$$a = \frac{A_s f_y + P_u / \phi}{0.80 f'_m b}$$

$$P_{\text{max}} = 0.00938$$

$$P = \frac{A_s}{b d} = \frac{0.62 \text{ in}^2}{15.6 \text{ in} \times 11.8 \text{ in}} = 0.00337$$

Combined Bending and Axial Load

CMU Pilaster Design

$h = 24 \text{ ft}$

o.c. spacing = 16 ft

$f'm = 2000 \text{ psi}$

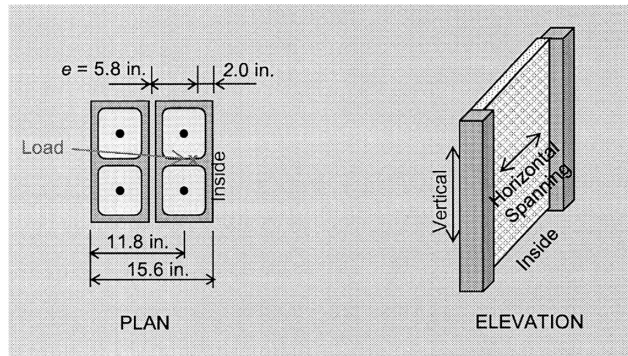
Gr 60 reinforcement, $f_y = 60 \text{ ksi}$

reinforcement not laterally tied

eccentricity = 5.8 in.

$D = 9.6 \text{ k}$ $S = 9.6 \text{ k}$ $W = 8.1 \text{ k}$ (uplift) $W = 26 \text{ psf}$ (lateral)

Load combination: $0.9 D - 1.0 W$



Loads:

Check load combination $0.9D + 1.0W$ as it usually controls.

Pilaster weight (fully grouted): $75 \text{ psf}(1.33 \text{ ft})(2 \text{ wythes}) = 200 \text{ lb/ft}$

Axial load at top of pilaster, P_{uf} : $0.9(9,600 \text{ lb}) - 1.0(8,100 \text{ lb}) = 540 \text{ lb}$

Axial load at midheight: $P_u = P_{uf} + P_{u,pilaster} = 540 \text{ lb} + 0.9(200 \text{ lb/ft})(12 \text{ ft}) = 2,700 \text{ lb}$

Combined Bending and Axial Load

CMU Pilaster Design

Given:

$h = 24 \text{ ft}$

o.c. spacing = 16 ft

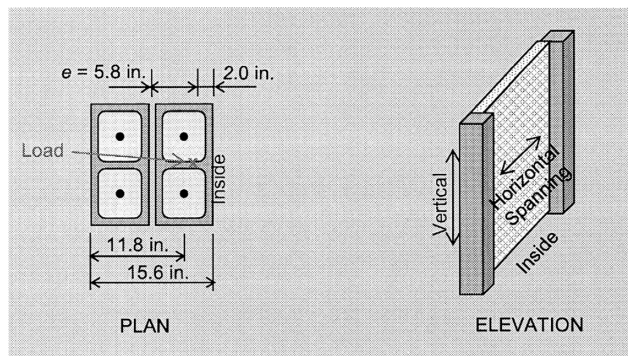
$f'm = 2000 \text{ psi}$

Gr 60 reinforcement, $f_y = 60 \text{ ksi}$

reinforcement not laterally tied

eccentricity = 5.8 in.

$D = 9.6 \text{ k}$ $W = 8.1 \text{ k}$ (uplift) $W = 26 \text{ psf}$ (lateral) Load Case: $0.9 D + 1.0 W$



Find: A_s , steel reinforcement

1. Find M_u :

Out-of-plane wind load on pilaster: $(26 \text{ psf})(16 \text{ ft}) = 416 \text{ lb/ft}$

Axial load at top of pilaster, P_{uf} : $0.9(9,600 \text{ lb}) - 1.0(8,100 \text{ lb}) = 540 \text{ lb}$

The maximum moment will occur approximately at the midheight of the pilaster.

$$M_u = \frac{w_u h^2}{8} + \frac{P_{uf} e}{2} = \frac{416 \text{ lb/ft}(24 \text{ ft})^2}{8} + \frac{(540 \text{ lb})(5.8/12 \text{ ft})}{2} = 30,100 \text{ lb-ft} = 361,000 \text{ lb-in.}$$

Combined Bending and Axial Load

CMU Pilaster Design

Determine c

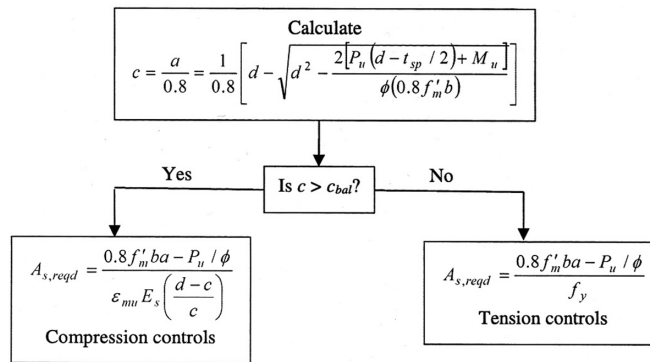
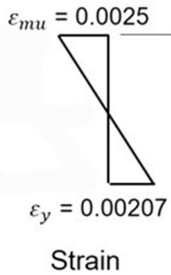


Figure 12.4-4 Flow Chart for Strength Design of Flexure and Axially Loaded Members

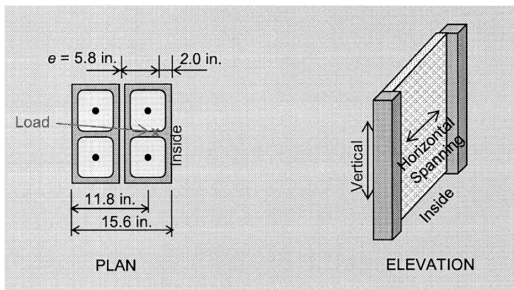
balanced strain

Estimate required area of steel, $A_{s,reqd}$. Use the flow chart in MDG Figure 12.4-4.

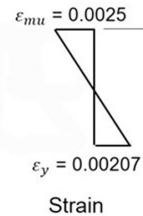
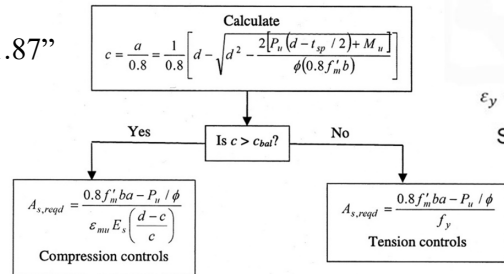
$$\text{Depth to neutral axis: } c = \frac{1}{0.8} \left[d - \sqrt{d^2 - \frac{2[P_u(d - t_{sp}/2) + M_u]}{\phi(0.8f'_m b)}} \right]$$

$$c = \frac{1}{0.8} \left[11.8 \text{ in.} - \sqrt{(11.8 \text{ in.})^2 - \frac{2[2,700 \text{ lb}(11.8 \text{ in.} - (15.6 \text{ in.})/2) + 361,000 \text{ lb} \cdot \text{in.}]}{0.9(0.8)(2,000 \text{ psi})(15.6 \text{ in.})}} \right] = 1.87 \text{ in.}$$

Combined Bending and Axial Load CMU Pilaster Design



$c = 1.87''$



$$\text{Is } c \geq c_{bal}?$$

For CMU, Grade 60 steel $c_{bal} = \frac{\epsilon_{mu}}{\epsilon_{mu} + \epsilon_y} d$
 $c_{bal} = 0.547d$

Figure 12.4-4 Flow Chart for Strength Design of Flexure and Axially Loaded Members

Balanced c : $c_{bal} = 0.547d = 0.547(11.8 \text{ in.}) = 6.45 \text{ in.}$

Since $c \leq c_{bal}$, tension controls.

Depth of stress block: $a = 0.8c = 0.8(1.87 \text{ in.}) = 1.50 \text{ in.}$

Required area of reinforcement: $A_{s,reqd} = \frac{0.8f'_m ba - P_u / \phi}{f_y}$

$$A_{s,reqd} = \frac{0.8(2,000 \text{ psi})(15.6 \text{ in.})(1.50 \text{ in.}) - 2,700 \text{ lb} / 0.9}{60,000 \text{ psi}} = 0.574 \text{ in.}^2$$

Combined Bending and Axial Load CMU Pilaster Design

$$A_{s,reqd} = 0.574 \text{ in}^2$$

$$\text{try } 2 \times \#5 \text{ bars, } A_s = 0.62 \text{ in}^2$$

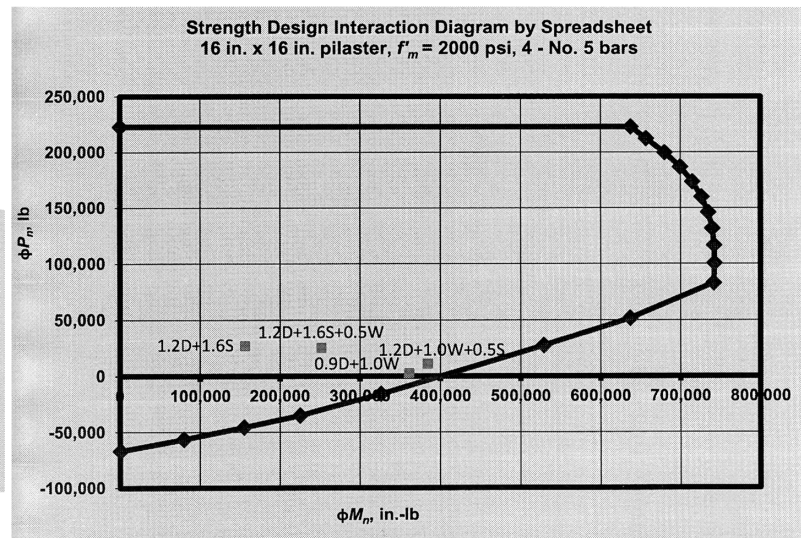
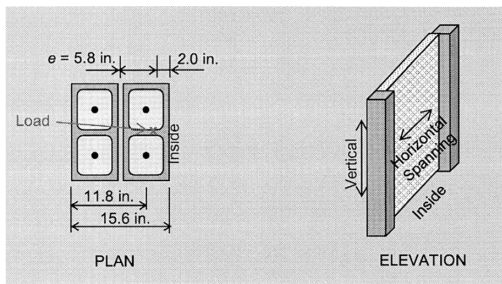
Since wind can be suction or pressure, bars are placed on both sides, symmetrically, in the center of each cell – total of 4 #5 bars.

$$\rho_{max} = \frac{0.64 f'_m \left(\frac{\epsilon_{mu}}{\epsilon_{mu} + 1.5 \epsilon_y} \right) \frac{P}{bd}}{f_y}$$

$$\rho = A_s/bd = 0.62/(15.6 \times 11.8) = 0.00336$$

$$P_u = 2,700 \text{ lbs}$$

$$M_u = 361,000 \text{ in-lbs}$$



Combined Bending and Axial Load example

Given:

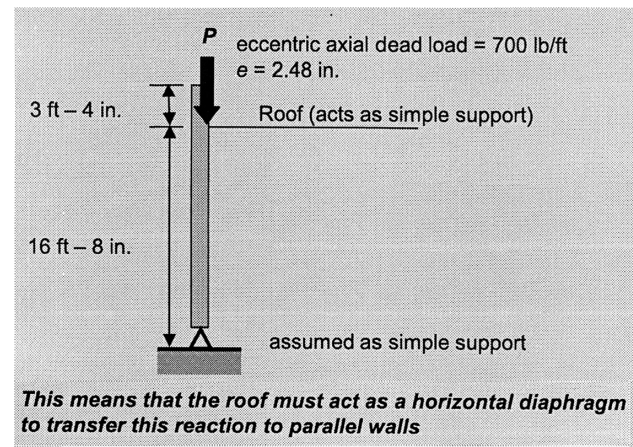
- exterior wall w/ parapet
- 30 psf wind
- eccentric roof, $e=2.48$ "
- wall DL = 44 psf
- Gr. 60 steel
- assume grout 48" o.c. (6 cells)
- 8" CMU w/ type S masonry cement
- load combination: $0.9D + 1.0W$

Required:

- Find the required steel reinforcement

Procedure:

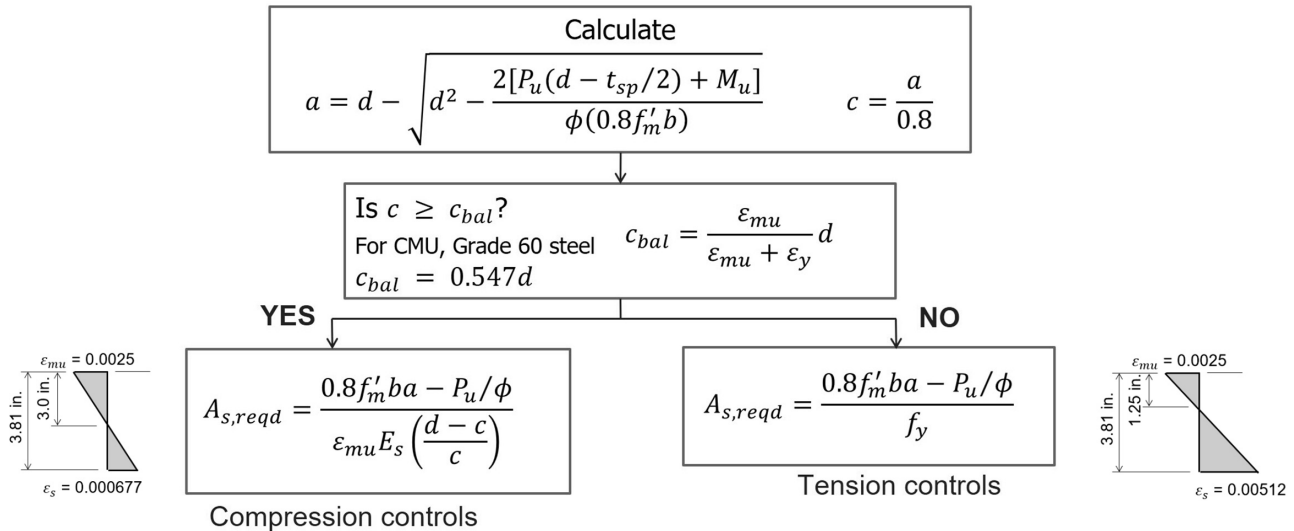
1. Calculate the initial (without magnifier) M_u and P_u
2. Calculate the moment magnifier, ψ
3. Determine the revised M_u and P_u
4. Determine combined force mode – tension or compression controlled
5. Find required steel, $A_{s,reqd}$



Combined Bending and Axial Load example

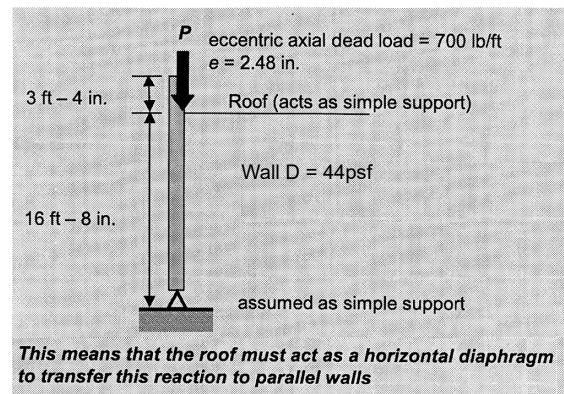
Procedure:

1. Calculate the initial (without magnifier) M_u and P_u
2. Calculate the moment magnifier, ψ
3. Determine the revised M_u and P_u
4. Determine combined force mode – tension or compression controlled
5. Find required steel, $A_{s,reqd}$



Combined Bending and Axial Load example

1. Calculate the initial (without magnifier) M_u and P_u



Calculate original moment, $M_{u,o}$ (without ψ)

The maximum moment will occur approximately at midheight of the wall, and can be determined as:

$$M_{u,o} = \frac{w_u h^2}{8} + \frac{P_{uf} e_u}{2} - \frac{1}{2} \frac{w_u h_{parapet}^2}{2}$$

$$= \left[\frac{(30 \text{ psf})(16.67 \text{ ft})^2}{8} + \frac{0.9(700 \text{ lb/ft})(2.48 \text{ in.}/12 \text{ ft})}{2} - \frac{1}{2} \frac{(30 \text{ psf})(3.33 \text{ ft})^2}{2} \right] 12 \text{ in.}$$

$$= 13,100 \text{ lb-in./ft}$$

Calculate P_u

The axial load at midheight is:

$$P_u = 0.9D = 0.9 (700 \text{ lb/ft} + 44 \text{ psf} (3.33 \text{ ft} + 16.67 \text{ ft} / 2)) = 1,090 \text{ lb/ft}$$

Combined Bending and Axial Load example

2. Find the moment magnification factor, ψ

$$M_u = \psi M_{u,0} \quad (\text{Equation 9-27})$$

Where $M_{u,0}$ is the strength level moment from first-order analysis.

$$\psi = \frac{1}{1 - \frac{P_u}{P_e}} \quad (\text{Equation 9-28})$$

Where:

$$P_e = \frac{\pi^2 E_m I_{eff}}{h^2} \quad (\text{Equation 9-29})$$

For $M_u < M_{cr}$, I_{eff} shall be taken as $0.75I_n$. For $M_u \geq M_{cr}$, I_{eff} shall be taken as I_{cr} . P_u/P_e cannot exceed 1.0.

Calculate M_{cr} and compare with M_u (estimate $\psi = 1.1$)

$$M_u = 1.1(13100) = 14410 \text{ in-lb/ft}$$

$$M_{cr} = 8260 \text{ in-lb/ft}$$

therefore, section is cracked

Cracking Moment:

Type S masonry cement, tension normal to the bed joint, TMS 402 Table 9.1.9.2

UngROUTED: $f_r = 51$ psi Grouted: $f_r = 153$ psi

Modulus of rupture (linear interpolation):

$$\left(\frac{5 \text{ ungrouted cells}}{6 \text{ cells}} \right) 51 \text{ psi} + \left(\frac{1 \text{ grouted cell}}{6 \text{ cells}} \right) 153 \text{ psi} = 68 \text{ psi}$$

$$\text{Cracking Moment: } M_{cr} = \left(\frac{P_u}{A_n} + f_r \right) S_n = \left(\frac{1,090 \text{ lb/ft}}{40.7 \text{ in.}^2/\text{ft}} + 68 \text{ psi} \right) 87.1 \text{ in.}^3/\text{ft} = 8,260 \text{ lb-in./ft}$$

Combined Bending and Axial Load example

2. Find the moment magnification factor, ψ

$$I_{cr} = n \left(A_s + \frac{P_u t_{sp}}{f_y 2d} \right) (d - c)^2 + \frac{bc^3}{3} \quad (\text{Equation 9-30})$$

Calculate $I_{cr} = I_{eff}$

$$c = \frac{A_s f_y + P_u}{0.64 f'_m b} \quad (\text{Equation 9-31})$$

Cracked Moment of Inertia:

$$\text{Modular ratio: } n = \frac{E_s}{E_m} = \frac{29,000,000 \text{ psi}}{900(2,000 \text{ psi})} = \frac{29,000,000 \text{ psi}}{1,800,000 \text{ psi}} = 16.11$$

$$\text{Depth to neutral axis: } c = \frac{A_s f_y + P_u}{0.64 f'_m b} = \frac{0.05 \text{ in.}^2/\text{ft}(60,000 \text{ psi}) + 1,090 \text{ lb/ft}}{0.64(2,000 \text{ psi})(12 \text{ in./ft})} = 0.266 \text{ in.}$$

$$\begin{aligned} \text{Cracked moment of inertia: } I_{cr} &= n \left(A_s + \frac{P_u t_{sp}}{f_y 2d} \right) (d - c)^2 + \frac{bc^3}{3} \\ &= 16.11 \left(0.05 \text{ in.}^2/\text{ft} + \frac{1,090 \text{ lb/ft}}{60,000 \text{ psi}} (1) \right) (3.81 \text{ in.} - 0.266 \text{ in.})^2 + \frac{(12 \text{ in./ft})(0.266 \text{ in.})^3}{3} = 13.9 \text{ in.}^4/\text{ft} \end{aligned}$$

Combined Bending and Axial Load example

2. Calculate the moment magnification factor, ψ

$$\psi = \frac{1}{1 - \frac{P_u}{P_e}} \quad (\text{Equation 9-28})$$

Where:

Calculate P_e

$$P_e = \frac{\pi^2 E_m I_{eff}}{h^2} \quad (\text{Equation 9-29})$$

$$\text{Buckling load: } P_e = \frac{\pi^2 E_m I_{eff}}{h^2} = \frac{\pi^2 (1,800,000 \text{ psi})(13.9 \text{ in.}^4/\text{ft})}{(200 \text{ in.})^2} = 6,170 \text{ lb/ft}$$

Combined Bending and Axial Load example

2. Calculate the moment magnification factor, ψ

$$\psi = \frac{1}{1 - \frac{P_u}{P_e}} \quad (\text{Equation 9-28})$$

Where:

$$P_e = \frac{\pi^2 E_m I_{eff}}{h^2} \quad (\text{Equation 9-29})$$

Calculate ψ

$$\text{Moment magnifier: } \psi = \frac{1}{1 - \frac{P_u}{P_e}} = \frac{1}{1 - \frac{1,090 \text{ lb/ft}}{6,170 \text{ lb/ft}}} = 1.214$$

3. Determine the revised M_u and P_u

$$M_u = \psi M_{u,0} = 1.214(13100) = 15903 \text{ in-lb/ft}$$

$$P_u = 0.9 \text{ DL} = 0.9 (\text{floor} + \text{parapet} + \text{wall}/2) = 1090 \text{ lb/ft}$$

The axial load at midheight is:

$$P_u = 0.9D = 0.9 (700 \text{ lb/ft} + 44 \text{ psf} (3.33 \text{ ft} + 16.67 \text{ ft} / 2)) = 1,090 \text{ lb/ft}$$

Combined Bending and Axial Load example

4. Determine combined force mode: tension or compression controlled?

Determine c:

$$a = 0.2497 \text{ in.}$$

$$c = a/0.8 = 0.312 \text{ in.}$$

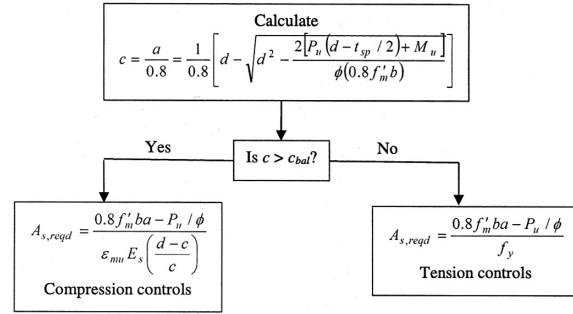


Figure 12.4-4 Flow Chart for Strength Design of Flexure and Axially Loaded Members

For centered reinforcement, which is often the case in walls, the axial force does not affect the value of c since $d = t_{sp}/2$ and thus $d - t_{sp}/2 = 0$.

$$c = \frac{1}{0.8} \left[d - \sqrt{d^2 - \frac{2[P_u(d - t_{sp}/2) + M_u]}{\phi(0.8f'_m b)}} \right]$$

$$= \frac{1}{0.8} \left[3.81 \text{ in.} - \sqrt{(3.81 \text{ in.})^2 - \frac{2[15903 \text{ lb-in./ft}]}{0.9(0.8)(2,000 \text{ psi})(12 \text{ in./ft})}} \right] = 0.312 \text{ in.}$$

Combined Bending and Axial Load example

4. Determine combined force mode: tension or compression controlled?

Determine c balanced

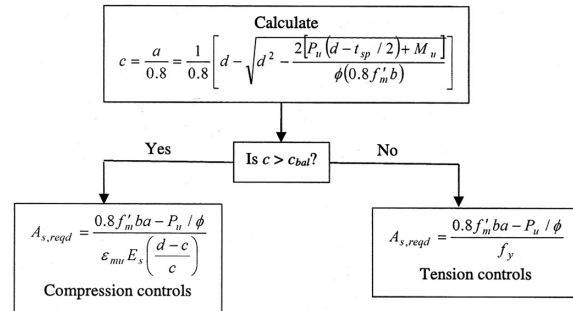


Figure 12.4-4 Flow Chart for Strength Design of Flexure and Axially Loaded Members

$$c_{bal} = d \cdot 0.547$$

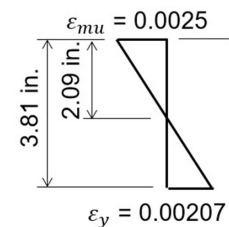
$$= (3.81) \cdot 0.547 = 2.084 \text{ in.}$$

Balance Point

$$\text{Location of neutral axis: } c = d \left(\frac{\epsilon_{mu}}{\epsilon_{mu} + \epsilon_y} \right) = 3.81 \text{ in.} \left(\frac{0.0025}{0.0025 + 0.00207} \right) = 2.08 \text{ in.}$$

$$c = 0.312 \text{ in.} < c_{bal} = 2.084 \text{ in.}$$

$c < c_{bal}$ therefore, tension controls



Strain

Combined Bending and Axial Load example

10. Determine $A_{s,reqd}$

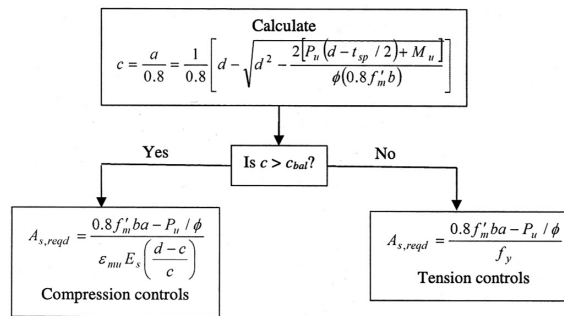


Figure 12.4-4 Flow Chart for Strength Design of Flexure and Axially Loaded Members

$$A_{s,reqd} = \frac{0.8f'_m ba - P_u / \phi}{f_y}$$

$$= \frac{0.8(2,000 \text{ psi})(12 \text{ in./ft})(0.249 \text{ in.}) - (1,090 \text{ lb/ft}) / 0.9}{60,000 \text{ psi}} = 0.0597 \text{ in.}^2 / \text{ft}$$

Combined Bending and Axial Load example

for $A_{s,reqd} = 0.597 \text{ in}^2/\text{ft}$

use #4 @ 40 in. o.c.

from TEK 14-01B

$A_n = 42.8 \text{ in}^2/\text{ft}$

$S_n = 88.3 \text{ in}^3/\text{ft}$

check M_{cr}

check capacity

check p max

Spacing (inches)	Steel Area in. ² /ft			
	#3	#4	#5	#6
8	0.16	0.30	0.46	0.66
16	0.082	0.15	0.23	0.33
24	0.055	0.10	0.16	0.22
32	0.041	0.075	0.12	0.16
40	0.033	0.060	0.093	0.13
48	0.028	0.050	0.078	0.11
56	0.024	0.043	0.066	0.094
64	0.021	0.038	0.058	0.082
72	0.018	0.033	0.052	0.073
80	0.016	0.030	0.046	0.066
88	0.015	0.027	0.042	0.060
96	0.014	0.025	0.039	0.055
104	0.013	0.023	0.036	0.051
112	0.012	0.021	0.033	0.047
120	0.011	0.020	0.031	0.044

Combined Bending and Axial Load example

for $A_s = 0.06 \text{ in}^2/\text{ft}$

use #4 @ 40 in. o.c.

from TEK 14-01B

$A_n = 42.8 \text{ in}^2/\text{ft}$

$S_n = 88.3 \text{ in}^3/\text{ft}$

$$a = \frac{A_s f_y + P_u / \phi}{0.80 f'_m b} = \frac{(0.06 \text{ in}^2/\text{ft})(60,000 \text{ psi}) + (1,090 \text{ lb}/\text{ft}) / 0.9}{0.80(2,000 \text{ psi})(12 \text{ in.}/\text{ft})} = 0.250 \text{ in.}$$

$$M_n = (P_u / \phi + A_s f_y) \left(d - \frac{a}{2} \right)$$

$$= \left((1,090 \text{ lb}/\text{ft}) / 0.9 + (0.06 \text{ in}^2/\text{ft})(60,000 \text{ psi}) \right) \left(3.81 \text{ in.} - \frac{0.250 \text{ in.}}{2} \right) = 17,729 \text{ lb} \cdot \text{in.}/\text{ft}$$

$$\phi M_n = 0.9(15,600 \text{ lb} \cdot \text{in.}/\text{ft}) = 15,956 \text{ lb} \cdot \text{in.}/\text{ft}$$

$$\phi M_n = 15,956 \text{ in-lb}/\text{ft} > 15,903 \text{ in-lb}/\text{ft} = M_u \quad \text{ok}$$

check capacity

check ρ max

(TMS 402 9.3.3.2)

$$\rho_{\max} = \frac{0.64 f'_m \left(\frac{\epsilon_{mu}}{\epsilon_{mu} + 1.5 \epsilon_y} \right) - \frac{P}{bd}}{f_y}$$

$$= \frac{0.64(2,000 \text{ psi}) \left(\frac{0.0025}{0.0025 + 1.5(0.00207)} \right) - \frac{700 \text{ lb}/\text{ft}}{(12 \text{ in.}/\text{ft})(3.81 \text{ in.})}}{60,000 \text{ psi}} = 0.00926$$

The actual reinforcement ratio is:

$$\rho = \frac{A_s}{bd} = \frac{0.06 \text{ in}^2/\text{ft}}{(12 \text{ in.}/\text{ft})(3.81 \text{ in.})} = 0.00131 \leq 0.00926 \quad \text{OK}$$