Solution:

A.) N-S DIRECTION: $L = 125'$, $d = 50'$

1. Maximum Unit (Roof) Diaphragm Shear, v_r

$w_s = V / L = (35{,}000 \text{ lbs}) / 125' = 280 \text{ plf}$

$V_1 = V_3 = w_s L / 2 = (280 \text{ plf})(125') / 2 = 17{,}500 \text{ lbs}$

roof $v_1 = v_3 = V_1 / d = (17{,}500 \text{ lbs}) / 50' = \boxed{350 \text{ plf}}$ (SD force level)

2. Maximum Unit Wall Shear, v_w

By inspection, the maximum unit wall shear will occur on line 3 (i.e., $V_1 = V_3$, $\Sigma b_3 = 25' < \Sigma b_1 = 30'$)

- Wall Line 1: $V_1 = V / 2$ & total shear wall width (i.e., length) - $\Sigma b_1 = 30'$
  wall $v_1 = V_1 / \Sigma b_1 = (17{,}500 \text{ lbs}) / 30' = 583 \text{ plf}$ (SD force level)

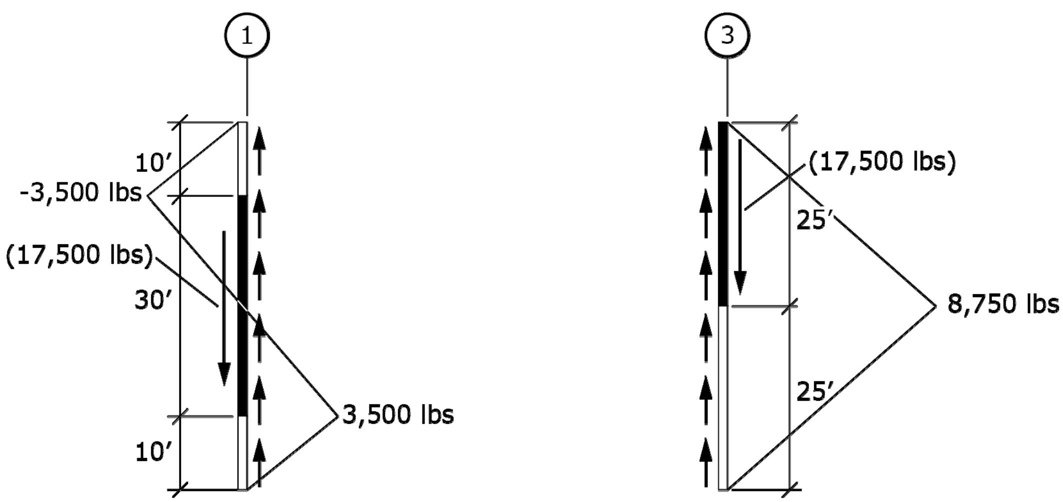
- Wall Line 3: $V_3 = V / 2$ & total shear wall width (i.e., length) - $\Sigma b_3 = 25'$
  wall $v_3 = V_3 / \Sigma b_3 = (17{,}500 \text{ lbs}) / 25' = \boxed{700 \text{ plf}}$ ← governs (SD force level)

3. Maximum Chord Force on lines A & B, *CF*

max. $CF = w_s L^2 / 8d$

$= (280 \text{ plf})(125')^2 / 8(50') = \boxed{10{,}940 \text{ lbs}}$ (SD force level)

4. Maximum Drag Force, F_d



Drag Force - Line 1 **Drag Force - Line 3**

By inspection, the maximum drag force will occur on line 3 -

- Wall Line 1: roof $v_1 = 350$ plf
  $F_d = v_1 (10') = (350 \text{ plf})(10') = 3{,}500 \text{ lbs}$ (SD force level)

- Wall Line 3: roof $v_3 = 350$ plf
  $F_d = v_3 (25') = (350 \text{ plf})(25') = \boxed{8{,}750 \text{ lbs}}$ ← governs (SD force level)

B.) <u>N-S DIRECTION</u>: Diaphragm span = $L_1 = L_2 = L / 2 = 62.5'$, $d = 50'$

1. Maximum Unit (Roof) Diaphragm Shear, v_r

The addition of the interior shear wall on line 2 will create two diaphragms that span equal amounts (e.g., $L_1 = L_2 = L / 2$). One diaphragm spans from line 1 to line 2, and the other diaphragm spans from line 2 to line 3.

$w_s = V / L$ = (35,000 lbs) / 125′ = 280 plf

$V_1 = V_3 = w_s (L_1 / 2) = w_s (L_2 / 2)$ = (280 plf)(62.5′) / 2 = 8,750 lbs

roof $v_1 = v_3 = V_1 / d$ = (8,750 lbs) / 50′ = **175 plf** (SD force level)

From Part A.1 - roof $v_1 = v_3$ = 350 plf → ∴ 50% reduction in max. unit (roof) diaphragm shear

2. Maximum Unit Wall Shear, v_w

By inspection, the maximum unit wall shear will occur on line 2 & 3 -

- <u>Wall Line 1</u>: $V_1 = V / 4$ & total shear wall length, $\Sigma b_1 = 30'$

  wall $v_1 = V_1 / \Sigma b_1$ = (8,750 lbs) / 30′ = 291 plf (SD force level)

- <u>Wall Line 2</u>: $V_2 = V / 2$ & total shear wall length, $\Sigma b_2 = 50'$

  wall $v_2 = V_2 / \Sigma b_2$ = (17,500 lbs) / 50′ = **350 plf** ← <u>governs</u> (SD force level)

- <u>Wall Line 3</u>: $V_3 = V / 4$ & total shear wall length, $\Sigma b_3 = 25'$

  wall $v_3 = V_3 / \Sigma b_3$ = (8,750 lbs) / 25′ = **350 plf** ← <u>governs</u> (SD force level)

From Part A.2 - wall v_3 = 700 plf → ∴ 50% reduction in max. unit wall shear

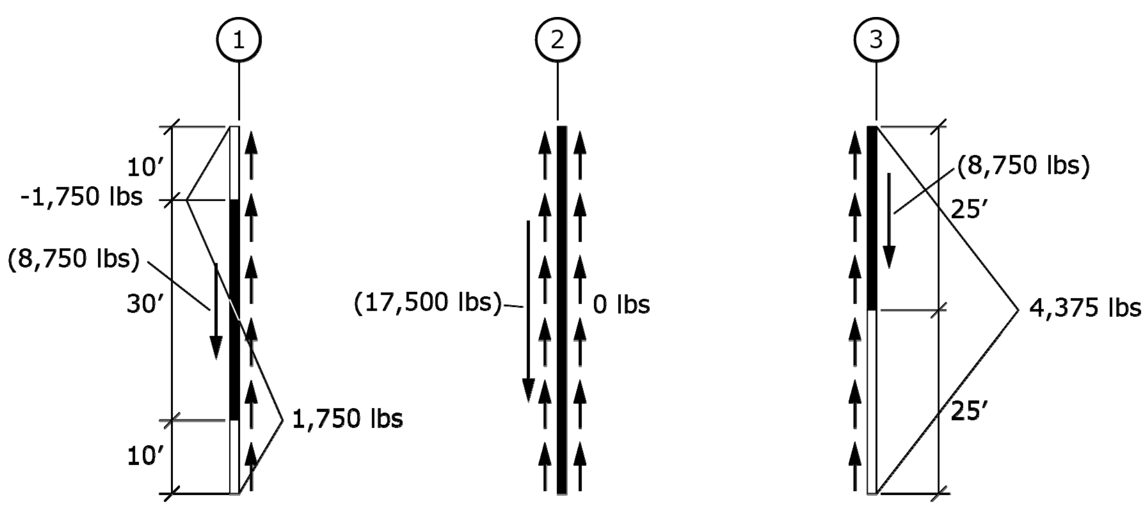
3. Maximum Chord Force on lines A & B, *CF*

max. $CF = w_s (L_1)^2 / 8d$

= (280 plf)(62.5′)^2 / 8(50′) = **2,730 lbs** (SD force level)

From Part A.3 - max. chord force CF = 10,940 lbs → ∴ 75% reduction in maximum chord force

4. Maximum Drag Force, F_d



Drag Force - Line 1 **Drag Force - Line 2** **Drag Force - Line 3**

Solution:

Office building = *Risk Category* II → *2012 IBC Table 1604.5*

$S_{DS} = 0.95$ → given

$I_e = 1.0$ → *ASCE 7 – Table 11.5-1*: *Risk Category* II

$R = 5½$ → *ASCE 7 – Table 12.2-1, item B.16*: Building Frame System – special reinforced masonry shear walls

NOTE: by observation, for a single story building … $T < T_S$ → ∴ *ASCE 7 (12.8-2)* will govern C_S

Seismic Response Coefficient, C_S

$$C_S = \frac{S_{DS}}{(R/I_e)} = \frac{(0.95)}{(5.5/1.0)} = \underline{0.173}$$ *ASCE 7 (12.8-2)*

Seismic Base Shear, V

$V = C_S W$ *ASCE 7 (12.8-1)*

$= \underline{0.173\ W}$ ← use for shear wall design

Diaphragm Design Force at Roof, F_{px}

$$F_{px} = \frac{\sum_{i=x}^{n} F_i}{\sum_{i=x}^{n} w_i} w_{px}$$ *ASCE 7 (12.10-1)*

For a single-story building (i.e., $F_1 = V$):

$$F_{p1} = \frac{C_S W}{W} w_{p1} = C_S\, w_{p1} = 0.173\ w_{p1}$$

$F_{p1} \le 0.4\ S_{DS}\ I_e\ w_{p1} = 0.4\ (0.95)(1.0)\ w_{p1} = 0.380\ w_{p1}$ maximum

$F_{p1} \ge 0.2\ S_{DS}\ I_e\ w_{p1} = 0.2\ (0.95)(1.0)\ w_{p1} = \underline{0.190}\ w_{p1}$ minimum ← use for roof diaphragm design

A.) N-S DIRECTION: $L = 70'$, $d = 40'$

1. Design Seismic Force to Diaphragm, $w_s = f_{p1} = F_{p1}/L$

roof DL + 20% snow; exterior walls

$w_s = f_{p1} = 0.190\ [(16\text{ psf} + 20\%\cdot 100\text{ psf})(40') + (85\text{ psf})(14'/2 + 2')(2\text{ walls})] = \boxed{564\text{ plf}}$

2. Unit Roof Shear on lines A & B, v_r

$V_A = V_B = w_s\ L / 2 = (564\text{ plf})(70'/2) = \underline{19{,}740\text{ lbs}}$

Unit roof shear, $v_A = v_B = V_A / d = (19{,}740\text{ lbs}) / 40' = \boxed{494\text{ plf}}$ (SD/LRFD force level)

3. Maximum Chord Force on lines 1 & 2, CF

max. $M = w_s\ L^2 / 8 = (564\text{ plf})(70')^2 / 8 = 345{,}450$ lb-ft

max. $CF = (345{,}450\text{ lb-ft}) / 40' = \boxed{8{,}636\text{ lbs}}$ (SD/LRFD force level)

9.27 What is the maximum length-width ratio for the blocked wood structural panel (WSP) horizontal diaphragms (second floor and roof)?

a. 2:1
b. 2½:1
c. 3:1
d. 4:1

9.28 Given a structure assigned to *Seismic Design Category* C with a typical *subdiaphragm* span of 20 feet, what would be the minimum required depth of each structural *subdiaphragm*?

a. 10′-0″
b. 8′-0″
c. 6′-8″
d. 5′-0″

9.29 What is the minimum seismic design force for structural *subdiaphragms* that are part of a flexible diaphragm in *SDC* = C, D, E or F?

a. $\frac{F_{px}}{L}$ plf
b. $\frac{F_x}{L}$ plf
c. $0.2K_aI_eW_p$
d. 280 plf

Given a single-story wood frame Police Station assigned to *Seismic Design Category* F with wood structural panels used for the flexible roof diaphragm and for the shear walls. The roof diaphragm is to use 19/32″ rated sheathing with 10d common nails (3″ x 0.148″) fastened to 2x nominal framing members, with blocking omitted at intermediate joints. The shear walls are to use 15/32″ Structural I sheathing with 10d common nails (3″ x 0.148″) fastened to 2x nominal framing members. Answer questions 9.30 through 9.33.

9.30 What is the allowable unit shear for the roof diaphragm with seismic loads perpendicular to the continuous panel joints?

a. 285 plf
b. 255 plf
c. 215 plf
d. 190 plf

9.31 What is the allowable unit shear for a shear wall with 4″ o.c. edge nailing, a height (h) of 12′-0″ and a width (b) of 8′-6″ resisting seismic loads?

a. 310 plf
b. 380 plf
c. 460 plf
d. 510 plf

Problem	Answer	Reference / Solution
		<u>Structure B</u> – By observation, *ASCE 7 (12.8-3)* will have to govern for Structure B for $V_A = V_B$ since T_B will have to be much larger than T_A to counteract the increase in effective seismic weight between structure A to structure B (i.e., $W_B = 3\ W_A$). Therefore, assume *ASCE 7 (12.8-3)* governs for C_S $C_{S\text{-}B} = S_{D1} / T_B\,(R / I_e)$ *ASCE 7 (12.8-3)* $V_B = C_{S\text{-}B}\, W_B$ *ASCE 7 (12.8-1)* Set the base shears equal – $V_A = V_B$ $C_{S\text{-}A}\, W_A = C_{S\text{-}B}\, W_B$ $S_{DS}\, W_A / (R / I_e) = S_{D1}\, 3W_A / T_B\,(R / I_e)$ → $W_A / (R / I_e)$ cancel from both sides of the equation → $S_{DS} = 3\ S_{D1} / T_B$ Solve for T_B – $T_B = 3\ S_{D1} / S_{DS}$ $T_B = 3\ (0.30\ ) / 0.73 = 1.23$ seconds ∴ <u>1.25 seconds</u> ←
4.85	b	p. 1-63, Structural Separation & *ASCE 7-10* p. 77, *§12.12.3* $\delta_M = \dfrac{C_d \delta_{\max}}{I_e}$ *ASCE 7 (12.12-1)* <u>Structure 1</u>: $C_d = 5½$ – *ASCE 7-10* p. 61*, Table 12.2.1- item C.1* for steel SMF At Level 4 - $\delta_{M1} = C_d\, \delta_{max} / I_e = (5½)(2.1'') / (1.00) = 11.55''$ At Level 7 (roof) - $\delta_{M1} = C_d\, \delta_{max} / I_e = (5½)(3.5'') / (1.00) = 19.25''$ <u>Structure 2</u>: $C_d = 4$ – *ASCE 7-10* p. 60*, Table 12.2.1- item B.16* for special masonry SW At Level 4 (roof) - $\delta_{M2} = C_d\, \delta_{max} / I_e = (4)(1.4'') / (1.00) = 5.60''$ **<u>NOTE</u>:** If Structure 1 and Structure 2 are to collide, that collision will occur at Level 4 for both structures, so that will be the level used to determine the required separation. Adjacent buildings on the same property, structural separation - $\delta_{MT} = \sqrt{(\delta_{M1})^2 + (\delta_{M2})^2}$ *ASCE 7 (12.12-2)* $= \sqrt{(11.55'')^2 + (5.60'')^2} = 12.80''$ ∴ <u>13 inches</u> ←
4.86	d	p. 1-63 to 64, Structural Separation & *ASCE 7-10* p. 77, *§12.12.3* From Problem 4.85 - <u>Structure 1</u>: At Level 7 (roof) - $\delta_{M1} = C_d\, \delta_{max} / I_e = (5½)(3.5'') / (1.00) = 19.25''$ Where a structure adjoins a property line (not common to a public way), the structure shall be set back from the property line by at least the displacement δ_M of <u>that</u> structure. *(continued)*