Find

1. Design capacity of the perforated shear wall line for wind and seismic shear resistance.
2. Base shear connection requirements.
3. Chord tension and compression forces.
4. Load-drift behavior of the perforated shear wall line and estimated drift at design load conditions.

Solution

1. Determine the factored and adjusted (design) shear capacity for the perforated shear wall line.

$F'_s = F_s\, C_{sp}\, C_{ns}\, [1/SF]$ (Eq. 6.5-1a)

$C_{sp} = [1\text{-}(0.5\text{-}0.42)] = 0.92$ (Section 6.5.2.3)
$C_{ns} = 0.75$ (Table 6.7)
$SF = 2.0$ (wind design) or 2.5 (seismic design) (Table 6.5)

$F_s = F_{s,ext} + F_{s,int}$ (Section 6.5.2.1)

$F_{s,ext} = 905$ plf (Table 6.1)
$F_{s,int} = 80$ plf (Table 6.3)

For wind design

$F_{s,wind} = 905 \text{ plf} + 80 \text{ plf} = 985 \text{ plf}$
$F'_{s,wind} = (985 \text{ plf})(0.92)(0.75)(1/2.0) = 340 \text{ plf}$

For seismic design

$F_{s,seismic} = 905 \text{ plf} + 0 \text{ plf} = 905 \text{ plf}$
$F'_{s,seismic} = (905 \text{ plf})(0.92)(0.75)(1/2.5) = 250 \text{ plf}$

The design capacity of the perforated shear wall is now determined as follows:

$F_{psw} = F'_s\, C_{op}\, C_{dl}\, L$ (Eq. 6.5-1b)

where,

$C_{op} = r/(3\text{-}2r)$
$r = 1/(1+\alpha/\beta)$
$\alpha = \Sigma A_o/(h \times L) = (A_1 + A_2)/(h \times L)$
$= (16.6 \text{ sf} + 21.8 \text{ sf})/(8 \text{ ft})(19 \text{ ft}) = 0.25$
$\beta = \Sigma L_i/L = (L_1 + L_2 + L_3)/L$
$= (3 \text{ ft} + 2 \text{ ft} + 8 \text{ ft})/(19 \text{ ft}) = 0.68$
$r = 1/(1+0.25/0.68) = 0.73$
$C_{op} = 0.73/(3\text{-}2(0.73)) = 0.47$

$C_{dl} = 1 + 0.15(w_D/300) \leq 1.15$

Assume for the sake of this example that the roof dead load supported at the top of the wall is 225 plf and that the design wind uplift force on the top of the wall is 0.6(225 plf) – 400 plf = -265 plf (net design uplift). Thus, for wind design in this case, no dead load can be considered on the wall and the C_{dl} factor does not apply for calculation of the perforated shear wall resistance to wind loads. It does apply to seismic design, as follows:

$w_D = 0.6*(225 \text{ plf}) = 135 \text{ plf}$

*The 0.6 factor comes from the load combinations 0.6D + (W or 0.7E) or 0.6D – W_u as given in Chapter 3.

$C_{dl} = 1 + 0.15(135/300) = 1.07$

For wind design,

$F_{psw,wind} = (340 \text{ plf})(0.47)(1.0)(19 \text{ ft}) = 3{,}036 \text{ lb}$

For seismic design,

$F_{psw,seismic} = (250 \text{ plf})(0.47)(1.07)(19 \text{ ft}) = 2{,}389 \text{ lb}$

Note: In Example 6.1 using the segmented shear wall approach, the design shear capacity of the wall line was estimated as 4,237 lb (wind) and 3,010 lb (seismic) when all of the segments were restrained against overturning by use of hold-down devices. However, given that the design shear load on the wall is 3,000 lb (wind) and 1,000 lb (seismic), the perforated shear wall design capacity as determined above is adequate, although somewhat less than that of the segmented shear wall. Therefore, hold-downs are only required at the wall ends (see Step 3).

2. Determine the base shear connection requirement for the perforated shear wall.

If the wall had a continuous bottom plate that serves as a distributor of the shear forces resisted by various portions of the wall, the base shear connection could be based on the perforated shear wall's design capacity as determined in Step 1 as follows:

For wind design,

Uniform base shear = (3,036 lb)/19 ft = 160 plf

For seismic design,

Uniform base shear = (2,389 lb)/19 ft = 126 plf

However, the wall bottom plate is not continuous in this example and, therefore, the base shears experienced by the portions of the wall to the left and right of the door opening are different as was the case in the segmented shear wall design approach of Example 6.1. As a conservative solution, the base shear connection could be designed to resist the design unit shear capacity of the wall construction, $F'_{s,wind}$ = 340 plf or $F'_{s,seismic}$ = 250 plf. Newer codes that recognize the perforated shear method may require this more conservative approach to be used when the bottom plate is not continuous such that it serves as a distributor (i.e., similar in function to a shear wall collector except shear transfer is out of the wall instead of into the wall). Of course, the bottom plate must be continuous and any splices must be adequately detailed in a fashion similar to collectors (see Example 6.3).