6.5.2.5 Shear Transfer (Sliding)

The sliding shear at the base of a shear wall is equivalent to the shear load input to the wall. To ensure that the sliding shear force transfer is balanced with the shear capacity of the wall, the connections at the base of the wall are usually designed to transfer the design unit shear capacity F'_s of the shear wall. Generally, the connections used to resist sliding shear include anchor bolts (fastening to concrete) and nails (fastening to wood framing). Metal plate connectors may also be used (consult manufacturer literature). In what is a conservative decision, frictional resistance and “pinching” effects usually go ignored. However, if friction is considered, a friction coefficient of 0.3 may be multiplied by the dead load normal to the slippage plane to determine a nominal resistance provided by friction.

As a modification to the above rule, if the bottom plate is continuous in a perforated shear wall, the sliding shear resistance is the capacity of the perforated shear wall F_{psw}. If the bottom plate is not continuous, then the sliding shear should be designed to resist the design unit shear capacity of the wall construction F'_s as discussed above. Similarly, if the restrained shear wall segments in a segmented shear wall line are connected to a continuous bottom plate extending between shear wall segments, then the sliding shear can be distributed along the entire length of the bottom plate. For example, if two 4-foot shear wall segments are located in a wall 12 feet long with a continuous bottom plate, then the unit sliding shear resistance required at the bottom plate anchorage is (8 ft)(F'_s)/(12 ft) or 2/3(F'_s). This is similar to the mechanism by which a unit shear load is transferred from a horizontal diaphragm to the wall top plate and then into the shear wall segments through a collector (i.e., top plate). Chapter 7 addresses design of the above types of shear connections.

6.5.2.6 Shear Wall Stiffness and Drift

The methods for predicting shear wall stiffness or drift in this section are based on idealized conditions representative solely of the testing conditions to which the equations are related. The conditions do not account for the many factors that may decrease the actual drift of a shear wall in its final construction. As mentioned, shear wall drift is generally overestimated in comparison with actual behavior in a completed structure (see Section 6.2 on whole-building tests). The degree of overprediction may reach a factor of 2 at design load conditions. At capacity, the error may not be as large because some nonstructural components may be past their yield point.

At the same time, drift analysis may not consider the factors that also increase drift, such as deformation characteristics of the hold-down hardware (for hardware that is less stiff than that typically used in testing), lumber shrinkage (i.e., causing time-delayed slack in joints), lumber compression under heavy shear wall compression chord load, and construction tolerances. Therefore, the results of a drift analysis should be considered as a guide to engineering judgment, not an exact prediction of drift.

The load-drift equations in this section may be solved to yield shear wall resistance for a given amount of shear wall drift. In this manner, a series of shear wall segments or even perforated shear walls embedded within a given wall line may be combined to determine an overall load-drift relationship for the entire wall line. The load-drift relationships are based on the nonlinear behavior of wood-framed shear walls and provide a reasonably accurate means of determining the behavior of walls of various configurations. The relationship may also be used for determining the relative stiffness of shear wall lines in conjunction with the relative stiffness method of distributing lateral building loads and for considering torsional behavior of a building with a nonsymmetrical shear wall layout in stiffness and in geometry. The approach is fairly straightforward and is left to the reader for experimentation.

Perforated Shear Wall Load-Drift Relationship

The load-drift equation below is based on several perforated shear wall tests already discussed in this chapter. It provides a nonlinear load-drift relationship up to the ultimate capacity of the perforated shear wall as determined in Section 6.5.2.2. When considering shear wall load-drift behavior in an actual building, the reader is reminded of the aforementioned accuracy issues; however, accuracy relative to the test data is reasonable (i.e., plus or minus 1/2-inch at capacity).

$$\Delta = 1.8\left(\frac{0.5}{G}\right)\left(\frac{1}{\sqrt{r}}\right)\left(\frac{V_d}{F_{PSW,ULT}}\right)^{2.8}\left[\frac{h}{8}\right] \text{ (inches)} \qquad \text{Eq. 6.5-8}$$

where,

Δ = the shear wall drift (in) at shear load demand, V_d (lb)

G = the specific gravity of framing lumber (see Table 6.6)

r = the sheathing area ratio (see Section 6.5.2.3, C_{op})

V_d = the shear load demand (lb) on the perforated shear wall; the value of V_d is set at any unit shear demand less than or equal to $F_{psw,ult}$ while the value of V_d should be set to the design shear load when checking drift at design load conditions

$F_{psw,ult}$ = the unfactored (ultimate) shear capacity (lb) for the perforated shear wall (i.e., F_{psw} x *SF* or F_{psw}/ϕ for ASD and LRFD, respectively)

h = the height of wall (ft)

Segmented Shear Wall Load-Drift Relationship

APA Semiempirical Load-Drift Equation

Several codes and industry design guidelines specify a deflection equation for shear walls that includes a multipart estimate of various factors' contribution to shear wall deflection (ICBO, 1997; ICC, 1999, APA, 1997). The approach relies on a mix of mechanics-based principles and empirical modifications. The principles and modifications are not repeated here because the APA method of