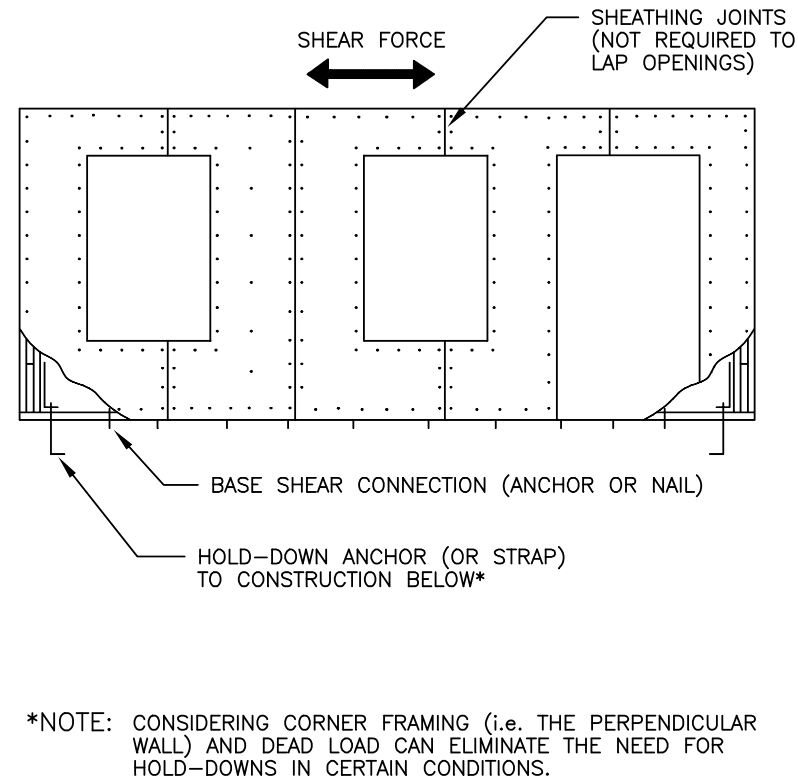
FIGURE 6.5 ***Illustration of a Basic Perforated Shear Wall***



The PSW design method requires the least amount of special construction detailing and analysis among the current shear wall design methods. It has been validated in several recent studies in the United States but dates back more than 20 years to research first conducted in Japan (Dolan and Heine, 1997a and b; Dolan and Johnson, 1996a and 1996b; NAHBRC, 1997; NAHBRC, 1998; NAHBRC, 1999; Sugiyama and Matsumoto, 1994; Ni et al., 1998). While it produces the simplest form of an engineered shear wall solution, other methods such as the segmented shear wall design method–all other factors equal–can yield a stronger wall. Conversely, a PSW design with increased sheathing fastening can outperform an SSW with more hold-downs but weaker sheathing fastening. The point is, that for many applications, the PSW method often provides an adequate and more efficient design. Therefore, the PSW method should be considered an option to the SSW method as appropriate.

Enhancements to the PSW Approach

Several options in the form of structural optimizations (i.e., "getting the most from the least") can enhance the PSW method. One option uses multiple metal straps or ties to restrain each stud, thereby providing a highly redundant and simple method of overturning restraint. Unfortunately, this promising enhancement has been demonstrated in only one known proof test of the concept (NAHBRC, 1999). It can, however, improve shear wall stiffness and increase capacity beyond that achieved with either the basic PSW method or SSW design approach. Another option, subjected to limited study by the NAHB Research Center, calls for perforated shear walls with metal truss plates at key framing joints (NAHBRC, 1998). To a degree similar to that in the first option, this enhancement increases shear capacity and stiffness without the use of any special hold-downs or restraining devices other than conventional framing connections at the base of the wall (i.e., nails or anchor bolts). Neither of the above options applied dead loads to the tested walls, such application would have improved performance. Unfortunately, the results do not lend themselves to easy duplication by analysis and must be used at their face value as empirical evidence to justify practical design improvements for conditions limited by the tests. Analytic methods are under development to facilitate use of optimization concepts in shear wall design and construction.

In a mechanics-based form of the PSW, analytic assumptions using free-body diagrams and principles of statics can conservatively estimate restraining forces that transfer shear around openings in shear walls based on the assumption that wood-framed shear walls behave as rigid bodies with elastic behavior. As compared to several tests of the perforated shear wall method discussed above, the mechanics-based approach leads to a conservative solution requiring strapping around window openings. In a condition outside the limits for application of the PSW method, a mechanics-based design approach for shear transfer around openings provides a reasonable alternative to traditional SSW design and the newer empirically based PSW design. The added detailing merely takes the form of horizontal strapping and blocking at the top and bottom corners of window openings to transfer the calculated forces derived from free-body diagrams representing the shear wall segments and sheathed areas above and below openings. For more detail, the reader should consult other sources of information on this approach (Diekmann, 1986; ICBO, 1997; ICC, 1999).

6.4.3 Basic Diaphragm Design Approach

As described in Chapter 2 and earlier in this section, horizontal diaphragms are designed by using the analogy of a deep beam laid flatwise. Thus, the shear forces in the diaphragm are calculated as for a beam under a uniform load (refer to Figure 6.4). As is similar to the case of shear walls, the design shear capacity of a horizontal diaphragm is determined by multiplying the diaphragm depth (i.e., depth of the analogous deep beam) by the tabulated unit shear design values found in building codes. The chord forces (in the “flange” of the analogous deep beam) are calculated as a tension force and compression force on opposite sides of the diaphragm. The two forces form a force couple (i.e., moment) that resists the bending action of the diaphragm (refer to Figure 6.1).

To simplify the calculation, it is common practice to assume that the chord forces are resisted by a single chord member serving as the “flange” of the deep beam (i.e., a band joist). At the same time, bending forces internal to the diaphragm are assumed to be resisted entirely by the boundary member or band joist rather than by other members and connections within the diaphragm. In