Design Example 6.5 of Section 6.6 elaborates on and demonstrates the use of the methods of load distribution described above. The reader is encouraged to study and critique them. The example contains many concepts and insights that cannot be otherwise conveyed without the benefit of a "real" problem.

6.5.2 Shear Wall Design

6.5.2.1 Shear Wall Design Values (F_s)

This section provides unfactored (ultimate) unit shear values for wood-framed shear wall constructions that use wood structural panels. Other wall constructions and framing methods are included as an additional resource. The unit shear values given here differ from those in the current codes in that they are based explicitly on the ultimate shear capacity as determined through testing. Therefore, the designer is referred to the applicable building code for "code-approved" unit shear values. This guide uses ultimate unit shear capacities as its basis to give the designer an explicit measure of the actual capacity and safety margin (i.e., reserve strength) used in design and to provide for a more consistent safety margin across various shear wall construction options. Accordingly, it is imperative that the values used in this guide are appropriately adjusted in accordance with Sections 6.5.2.2 and 6.5.2.3 to ensure an acceptable safety margin.

Wood Structural Panels (WSP)

Table 6.1 provides unit shear values for walls sheathed with wood structural panels. It should be noted again that these values are estimates of the ultimate unit shear capacity values as determined from several sources (Tissell, 1993; FEMA, 1997; NAHBRC, 1998; NAHBRC, 1999; others). The design unit shear values in today's building codes have inconsistent safety margins that typically range from 2.5 to 4 after all applicable adjustments (Tissell, 1993; Soltis, Wolfe, and Tuomi, 1983). Therefore, the actual capacity of a shear wall is not explicitly known to the designer using the codes' allowable unit shear values. Nonetheless, one alleged benefit of using the code-approved design unit shear values is that the values are believed to address drift implicitly by way of a generally conservative safety margin. Even so, shear wall drift is usually not analyzed in residential construction for reasons stated previously.

The values in Table 6.1 and today's building codes are based primarily on monotonic tests (i.e., tests that use single-direction loading). Recently, the effect of cyclic loading on wood-framed shear wall capacity has generated considerable controversy. However, cyclic testing is apparently not necessary when determining design values for seismic loading of wood-framed shear walls with structural wood panel sheathing. Depending on the cyclic test protocol, the resulting unit shear values can be above or below those obtained from traditional monotonic shear wall test methods (ASTM, 1998a; ASTM, 1998b). In fact, realistic cyclic testing protocols and their associated interpretations were found to be largely in agreement with the results obtained from monotonic testing (Karacabeyli and Ceccotti, 1998). The differences are generally in the range of 10 percent (plus or minus) and thus seem moot given that the seismic response modifier (see Chapter 3) is based on expert opinion (ATC, 1995) and that the actual performance of light-frame homes does not appear to correlate with important parameters in existing seismic design methods (HUD, 1999), among other factors that currently contribute to design uncertainty.

TABLE 6.1 ***Unfactored (Ultimate) Shear Resistance (plf) for Wood Structural Panel Shear Walls with Framing of Douglas-Fir, Larch, or Southern Pine***[1,2]

			Panels Applied Direct to Framing				
				Nail Spacing at Panel Edges (inches)			
Panel Grade	Nominal Panel Thickness (inches)	Minimum Nail Penetration in Framing (inches) (APA, 1998)	Nail Size (common or galvanized box)	6	4	3	2[3]
Structural I	5/16	1-1/4	6d	821	1,122	1,256	1,333
	3/8[4]	1-3/8	8d	833	1,200	1,362	1,711
	7/16[4]	1-3/8	8d	905	1,356	1,497	1,767
	15/32	1-3/8	8d	977	1,539	1,722	1,800
	15/32	1-1/2	10d[5]	1,256	1,701	1,963	2,222

Notes:
[1]Values are average ultimate unit shear capacity for walls sheathed with Structural I wood structural panels and should be multiplied by a safety factor (ASD) or resistance factor (LRFD) in accordance with Sections 6.5.2.2 and 6.5.2.3. Additional adjustments to the table values should be made in accordance with those sections. For other rated panels (not Structural I), the table values should be multiplied by 0.85.
[2]All panel edges should be backed with 2-inch nominal or wider framing. Panels may be installed either horizontally or vertically. Space nails at 6 inches on center along intermediate framing members for 3/8-inch panels installed with the strong axis parallel to studs spaced 24 inches on-center and 12 inches on-center for other conditions and panel thicknesses.
[3]Framing at adjoining panel edges should be 3-inch nominal or wider and nails should be staggered where nails are spaced 2 inches on-center. A double thickness of nominal 2-inch framing is a suitable substitute.
[4]The values for 3/8- and 7/16-inch panels applied directly to framing may be increased to the values shown for 15/32-inch panels, provided that studs are spaced a maximum of 16 inches on-center or the panel is applied with its strong axis across the studs.
[5]Framing at adjoining panel edges should be 3-inch nominal or wider and nails should be staggered where 10d nails penetrating framing by more than 1-5/8 inches are spaced 3 inches or less on-center. A double thickness of 2-inch nominal framing is a suitable substitute.

The unit shear values in Table 6.1 are based on nailed sheathing connections. The use of elastomeric glue to attach wood structural panel sheathing to wood framing members increases the shear capacity of a shear wall by as much as 50 percent or more (White and Dolan, 1993). Similarly, studies using elastomeric construction adhesive manufactured by 3M Corporation have investigated seismic performance (i.e., cyclic loading) and confirm a stiffness increase of about 65 percent and a shear capacity increase of about 45 to 70 percent over sheathing fastened with nails only (Filiatrault and Foschi, 1991). Rigid adhesives may create even greater strength and stiffness increases. The use of adhesives is beneficial in resisting shear loads from wind. Glued shear wall panels are not recommended for use in high-hazard seismic areas because of the brittle failure mode experienced in the wood framing material (i.e., splitting), though at a significantly increased shear load. Gluing shear wall panels is also not recommended by panel manufacturers because of concern with panel buckling that may occur as a result of the interaction of rigid restraints with moisture/temperature expansion and contraction of the panels.