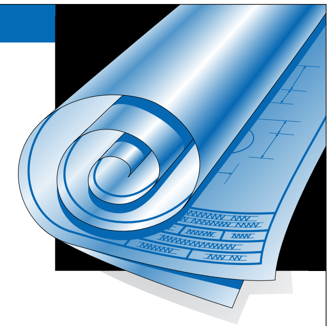
TECHNICAL NOTE



Wood Structural Panel Sheathing or Siding Used to Resist Combined Shear and Uplift

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As home builders strive to meet the requirements of building codes in areas of high wind, they are on the lookout for efficient solutions, typically in the form of uplift straps required at the top and bottom of every wall. Not only are the straps expensive to purchase and install, but they may interfere with the proper nailing of other elements of the structure, such as shear wall hold downs, shear wall panel nailing, and siding installation.

Over a decade ago, the idea of combining the uplift and shear capacities of the wood structural panel wall sheathing was investigated by *APA – The Engineered Wood Association*. Based on an analytical procedure, such guidelines were developed and published in the 1993 Standard Building Code's *Standard for Hurricane Resistant Residential Construction,* commonly known as SSTD-10. This standard was recently updated by the Institute for Business and Home Safety (IBHS) with the permission of the International Code Council (ICC) for use in the state of Florida in 2005 and renamed the *Guidelines for Hurricane Resistant Residential Construction*. In addition, the ICC established an ANSI committee to update the latest version of SSTD-10. In this technical note, the combined shear and uplift concept presented in the referenced documents is discussed. There are minor differences in details in the three documents mentioned due to the evolution of the concept. In generating this technical note, all the latest developments that are being considered by the ICC/ANSI committee are incorporated.

How can a panel that is stressed in shear be used for uplift as well?

Wood structural panels have a high shear capacity. Because of the limitations of nailed connections in lumber, only a small fraction of the panel shear capacity is actually used in a shearwall. It is true that putting a panel in tension reduces its shear capacity. There is, however, sufficient residual shear capacity left to permit the panels to be used in combined shear and uplift as presented by this paper.

The basic concept behind this paper and the referenced documents mentioned previously begins with a wood structural panel that is designed as a shear wall and has a specific attachment schedule associated with its desired shear capacity. To obtain additional uplift resistance from the panel, additional nails must be added to the shear nailing at the top and bottom of the panel. These additional nails are used to transfer the uplift from the top plate to the panel, from panel-to-panel at a splice location (if present) and from panel-to-sole-plate at the foundation, effectively eliminating the need for uplift straps at these locations. Uplift straps will still be required around window and door openings in exterior walls to transfer the uplift loads acting on the header to the foundation below.

APA
THE ENGINEERED WOOD ASSOCIATION

DESIGNING FOR COMBINED SHEAR AND UPLIFT

Wood structural panel sheathing or siding may be used to resist shear and uplift simultaneously provided the following conditions are met:

- Anchor bolt spacing shall be 16 inches or less on center,
- 3- x 3- x 0.229-inch steel plate washers shall be used at anchor bolt locations, and
- Nails in any single row shall not be spaced closer than 3 inches on center.

These conditions effectively eliminate the cross-grain bending as a failure mode in the bottom plate, as shown by the full-scale test results reported by independent testing organizations. Assuming the above conditions are met, the following steps may be used to design wood structural panel sheathing or siding to simultaneously resist shear and uplift.

Step 1 – Design the shear walls.

The first step in designing for combined shear and uplift is to design the required shear for the structure. This method may be used for either the conventional isolated shear wall method or the perforated shear wall method. When using the isolated method, a table similar to Table 1 below can be used to determine the required thickness, nail size, and spacing for the individual shear walls. Note that a minimum 7/16-inch or 15/32-inch wood structural panel sheathing or siding panel must be used. Table 1 has been edited to only show appropriately sized panels.

TABLE 1

SHEAR CAPACITIES FOR SHEARWALL MATERIALS

(Excerpts from the IBHS *Guidelines for Hurricane Resistant Residential Construction,* Table 305N1. Copyright 2005. Washington, DC: International Code Council. Reproduced with permission. All rights reserved. Courtesy of Institute for Business and Home Safety.)

			Framing Species G≥0.49				Framing Species 0.49>G≥0.42				Framing Species G<0.42			
			Panel Edge Nail Spacing (in.)[1]											
			6	4	3	2[2]	6	4	3	2[2]	6	4	3	2[2]
Sheathing Material	Sheathing Thickness (in.)	Nail Size[3]	Recommended Shear Capacity (plf)											
Structural I	7/16	8d	355	555	705	940	320	495	630	840	250	390	505	665
	15/32	8d	390	600	770	1020	320	495	630	840	250	390	505	665
		10d	475	715	930	1220	390	590	765	1000	310	460	600	790
Sheathing Grade, Plywood Siding	7/16	8d	335	490	630	820	320	490	630	820	250	390	505	665
	15/32	8d	365	530	685	895	320	495	630	840	250	390	505	665
		10d	435	645	840	1060	390	590	765	1000	310	460	600	790
	19/32	10d	475	715	930	1220	390	590	765	1000	310	460	600	790

G = Specific gravity of framing members.

1. Nails of the same size required for panel edges shall be placed along all intermediate framing at 12 inches on center.
2. Where panel edges abut, framing shall be a minimum of 3 inches nominal in thickness, and nails shall be staggered.
3. Common or galvanized box nails.

Table 1 was taken from the 2005 IBHS *Guidelines for Hurricane Resistant Residential Construction.* Similar tables are currently available in the 2006 International Building Code (Table 2306.4.1), the American Forest & Paper Association's (AF&PA) 2005 *Special Design Provisions for Wind and Seismic,* and APA's *Engineered Wood Construction Guide,* Form E30. The AF&PA 2001 *Wood Frame Construction Manual (WFCM) for One- and Two-Family Dwellings* contains a number of prescriptive tables (Tables 3.17A through 3.17E) that can also be used for residential-type structures to eliminate the engineering burden of designing shear walls.

When using the perforated shear wall method, an additional step is required in the shear wall design. This is the step where the Shear Resistance Adjustment Factor (C_o) is used to adjust the Table 1 design values for the geometry of the wall penetrations (see IBHS *Guidelines for Hurricane Resistant Residential Construction).* Once the perforated shear wall design is complete, however, the nailing type and schedule is used in exactly the same way as discussed in Step 3.

Information on the perforated shear wall design method is also available in Section 2305.2.8.2 of the 2006 *International Building Code* and in Section 4.4 of the AF&PA 2005 *Special Design Provisions for Wind and Seismic.*

Also note that wind uplift loads occurring at window or door headers, even in a perforated shear wall, must be distributed around the opening and into the structure below by way of hardware specifically designed for such applications.

Step 2 – Determine required uplift.

The required wind uplift at the top of the wall can be found prescriptively by using Table 2, which was taken from the AF&PA 2001 *Wood Frame Construction Manual.* Be sure to use the footnotes in Table 1 to adjust the table properties to the specific design case.

TABLE 2

UPLIFT CONNECTION LOADS FROM WIND (FOR ROOF-TO-WALL, WALL-TO-WALL, AND WALL-TO-FOUNDATION)
(Excerpts from Table 2.2A of the AF&PA 2001 *Wood Frame Construction Manual,* Courtesy of American Forest & Paper Association, Washington D.C.)

3-Second Gust Wind Speed (mph)		85	90	100	110	120	130	140	150
Roof/Ceiling Assembly Design Dead Load	Roof Span (ft)	Unit Connection Loads (plf)[1,2,3,4,5,6,7]							
0 psf[8]	12	119	134	165	199	237	279	323	371
	24	196	219	271	328	390	458	531	610
	36	273	306	378	457	544	639	741	850
	48	350	393	485	587	698	820	951	1091
	60	428	480	592	717	853	1001	1161	1333
10 psf	12	71	86	117	151	189	231	275	323
	24	112	135	187	244	306	374	447	526
	36	153	186	258	337	424	519	621	730
	48	194	237	329	431	542	664	795	935
	60	236	288	400	525	661	809	969	1141
15 psf	12	47	62	93	127	165	207	251	299
	24	70	93	145	202	264	332	405	484
	36	93	126	198	277	364	458	561	670
	48	116	159	251	353	464	586	717	857
	60	140	192	304	429	565	713	873	1045
20 psf	12	23	38	69	103	141	183	227	275
	24	28	51	103	160	222	290	363	442
	36	33	66	138	217	304	399	501	610
	48	38	81	173	275	386	508	639	779
	60	44	96	208	333	469	617	777	949
25 psf	12	–	14	45	79	117	159	203	251
	24	–	9	61	118	180	248	321	400
	36	–	6	78	157	244	339	441	550
	48	–	3	95	197	308	430	561	701
	60	–	0	112	237	373	521	681	853

1. Tabulated unit uplift connection loads shall be permitted to be multiplied by 0.75 for framing not located within 6 ft of corners for buildings less than 30 ft in width (W), or W/5 for buildings greater than 30 ft in width.
2. Tabulated uplift loads assume a building located in Exposure B with a mean roof height of 33 ft. For buildings located in other exposures, the tabulated values for 0 psf roof dead load shall be multiplied by the appropriate adjustment factor in the table below and then reduced by the appropriate dead load.

Mean Roof Height (ft)	**Exposure C**	**Exposure D**
0–15	1.18	1.43
20	1.25	1.50
25	1.31	1.56
30	1.36	1.61
33	1.39	1.64

3. Tabulated uplift loads are specified in pounds per linear ft of wall. To determine connection requirements, multiply the tabulated unit uplift load by the multiplier from the table below corresponding to the spacing of the connectors:

Connection Spacing (in.)	**12**	**16**	**19.2**	**24**	**48**
Multiplier	1.00	1.33	1.60	2.00	4.00

4. Tabulated uplift loads equal total uplift minus 0.6 of the roof/ceiling assembly design dead load.
5. Tabulated uplift loads are specified for roof-to-wall connections. When calculating uplift loads for wall-to-wall or wall-to-foundation connections, tabulated uplift loads shall be permitted to be reduced by 60 plf (0.60 x 100 plf) for each wall above.
6. When calculating uplift loads for ends of headers/girders, multiply the tabulated unit uplift load by 1/2 of the header/girder span (ft). Cripple studs need only be attached per typical uplift requirements.
7. For jack rafter uplift connection, use roof span equal to twice the jack rafter length. The jack rafter length includes the overhang length and the jack span.
8. Tabulated uplift loads for 0 psf design loads are included for interpolation or use with actual roof dead loads.

Step 3 – Determine combined shear and uplift nailing.

Enter Table 3 with the nail size and spacing determined in Step 1. Under this category, find an uplift capacity larger than or equal to the required wind uplift determined in Step 2.

TABLE 3

UPLIFT CAPACITY OF 15/32-INCH WOOD STRUCTURAL PANEL SHEATHING OR SIDING WHEN USED FOR BOTH SHEAR WALLS AND UPLIFT SIMULTANEOUS OVER SPRUCE-PINE-FIR OR EQUIVALENT FRAMING[1,2,3]

(From the April 2006 Errata to the IBHS *Guidelines for Hurricane Resistant Residential Construction,* Table 305S1. Copyright 2005. Washington, DC: International Code Council. Reproduced with permission. All rights reserved. Courtesy of Institute for Business and Home Safety.)

	Nail Spacing Required for Shear Wall Design – See Table 1											
	6d@6" & 12"			8d@6" & 12"			8d@4" & 12"			10d@6" & 12"		
	Alternate Nail Spacing at Top and Bottom Plate Edges (in.)											
	6	4	3	6	4	3	6	4	3	6	4	3
	Uplift Capacity (plf)[3]											
Nails-Single Row[4]	0	94	198	0	118	237	NP	0	118	0	142	285
Nails-Double Row[5]	189	377	566	237	474	710	118	355	592	285	570	855

1. **7/16-inch wood structural panels shall be permitted when supported by vertical framing at 16 inches on center or less.**
2. Anchor bolts shall be installed in accordance with this section.
3. For framing with a specific gravity of 0.49 or greater, divide uplift values listed in above table by 0.92.
4. Wood structural panels shall overlap the top member of the double top plate and bottom plate by 1-1/2 inches and a single row of fasteners shall be placed 3/4 inch from the panel edge.
5. Wood structural panels shall overlap the top member of the double top plate and bottom plate by 1-1/2 inches. Rows of fasteners shall be 1/2 inch apart with a minimum edge distance of 1/2 inch. Each row shall have nails at the specified spacing.

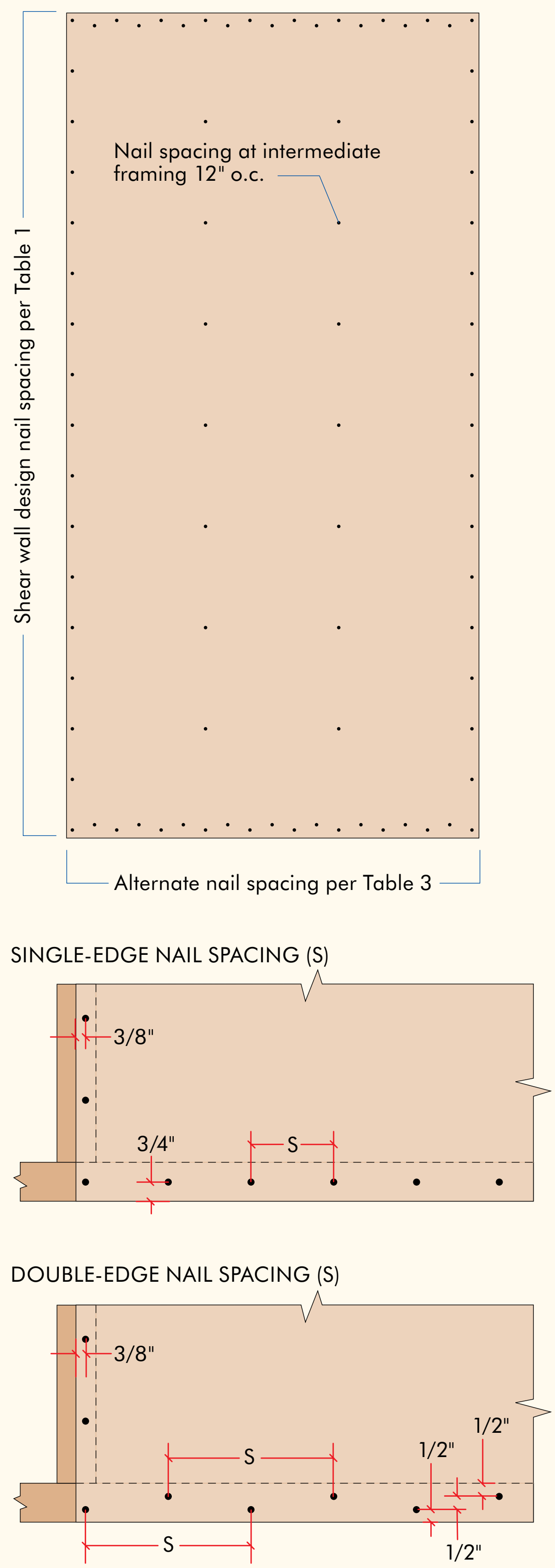
INSTALLATION

Once the design for the combined shear and uplift is complete, installation shall be as follows:

1. Multiple rows of nails applied at panel ends and edges shall be installed in accordance with Figure 1.
2. Panels shall be installed with strength axis parallel to studs.
3. All horizontal joints shall occur over framing and shall be attached per Figure 1.
4. On single-story construction, panels shall be attached to bottom plates and top member of the double top plate. Lowest plate shall be attached to foundation with minimum 5/8-inch bolts with minimum embedment of 7 inches or connectors of sufficient capacity to resist the uplift and shear forces developed in the wood structural panel sheathing or sided walls.
5. On two-story construction, upper panels shall be attached to the top member of the upper double top plate and to band joist at bottom of panel. Upper attachment of lower panel shall be made to band joist and lower attachment made to lowest plate at first-floor framing. Lowest plate of first-floor framing shall be attached to foundation with minimum 5/8-inch bolts with minimum embedment of 7 inches or connectors of sufficient capacity to resist the uplift and shear forces developed in the wood structural panel sheathing or sided walls.
6. Where windows and doors interrupt wood structural panel sheathing or siding, framing anchors or connectors shall be used to resist the appropriate uplift loads.

FIGURE 1

PANEL ATTACHMENT FOR UPLIFT



EXAMPLE

A designer wants to use a conventional isolated shear wall segment for combined shear and uplift. The shear on the given segment is 420 plf and, from Table 2, the designer ascertains that the uplift along this segment of wall is 615 plf. The framing, including bottom plate is southern pine (G = 0.55) with studs at 16 inches on center.

Step 1 – Design the shear walls.

From Table 1, using sheathing-grade wood structural panels, a 7/16-inch thickness is selected and attached with 8d nails at 4 inches on center at panel edges and 12 inches on center in the field of the panel. This yields a shear capacity of 490 plf.

490 > 420, therefore OK.

Step 2 – Determine required uplift.

Uplift force is given at 615 plf.

Step 3 - Determine combined shear and uplift nailing.

From Table 3, second line using 8d nails at 4 and 12 inches on center, find any number larger-than or equal-to 615 plf. There is not one. Notice, however, that a double row of nails at 3 inches on center yields a capacity of 592 plf and that Footnote 3 provides an 8 percent increase for framing with a specific gravity of 0.49 or higher. 592 plf/0.92 = 643 plf.

643 > 615, therefore OK.

The designer may specify a double row of 8d nails at 3 inches on center and satisfy the combined shear and uplift requirements for this wall segment. This segment is required to use 5/8-inch anchor bolts spaced at 16 inches on center with 3- x 3- x 0.229-inch square steel plate washers.

Note that the designer must still size the hold down for the ends of the isolated shear wall segment based only on the unit shear, as is done in shear walls designed for shear only. Similarly, for the perforated shear wall method, hold downs are required at the ends of the perforated wall and are designed in the same manner as walls without wind uplift.

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