Chapter 3
BASIC SHEAR WALL CONSTRUCTION
REQUIREMENTS AND SOLUTIONS

3.1

GENERAL ISSUES AND CONCERNS

This chapter addresses some installation situations that workers commonly face in the field. Note that you may encounter problems not mentioned here and that the solutions presented are general. For situations not described in this guide, contact a qualified design professional in your area. You can also submit cases not discussed here to www.shearwalls.com for inclusion in future editions of this book. The author will pay the first person who submits each new condition used in future publications.

The code intends that connections that resist seismic forces should be designed and detailed on the drawings. In the real world of design, engineers do not always get all the information required for a complete design down on paper. (This is why building departments employ plan checkers, and one reason why many design and code professionals recommend hiring the designer of a structure to observe it during construction.) Designers also have different levels of understanding of shear wall principles and construction and what is possible to build. Just having a professional’s seal and signature on a set of plans will not make the finished building perform well, or even stand up, during a hurricane or earthquake. This book will not help you if the approved plans show construction that attempts to violate the laws of physics. If something on your plans seems to contradict what common sense tells you after reading this book, have the designer explain it to you, preferably with sketches for clarification.

NOTE: See the shaded text on the next page for an explanation of why prescriptive designs may seem contrary to the material presented here.

This book is intended for builders rather than engineers. I have tried to present enough theory and research results to satisfy curious carpenters and builders; extensive discussion of theory would detract from the purpose of this book. The basic physical principles that make shear walls necessary will not change. Winds will blow and earthquakes will occur, and your house must transfer the resulting forces to its footings. Scientists and engineers keep refining their understanding of how shear walls behave during disasters. Further study will most likely result in things such as changing the type of steel in sheathing nails or coming up with new types of connection hardware. Such changes will not affect builders much; shear walls will still consist of sheathing, nails, framing, and tie-downs.

3.1.1 Code check or reality check?

This guide refers to the building codes (IBC and IRC) in several places. The model codes will continue to be refined in their requirements for design and construction of shear walls, but Mother Nature has universal requirements for them. Once you understand the physical principles that shear wall construction involves, understanding future code revisions will be much easier.
The various building codes are all intended to protect you and your house from natural disasters. The code provisions may vary from one code to another or change from time to time. Of course, the laws of physics that govern structural behavior remain in effect no matter what code is adopted. This guide attempts to explain why and how shear walls work. If you understand the physical principles you will recognize the importance of the related code provisions. You will even see why some things the code does not require are still important to include in your construction.

### 3.1.2 Poor building practices or failure of engineers to educate builders?

Many of the photos in the following sections show what one reviewer simply dismissed as poor building techniques. When I took most of the photos in early 2001, the cases illustrated were not uncommon. Furthermore, these problems seemed to be overlooked by inspectors (otherwise one would assume that they would not be repeated in tract after tract). This indicated that engineers had not made shear wall construction requirements clear to the construction industry. I wrote this guide to present proper shear wall construction methods while illustrating some of the more commonly seen problems. Once this information is widely available, carpenters and builders who take pride in their work will have the knowledge needed to properly construct shear walls.
3.1.3 Construction problems can compound each other

The following sections list many building requirements. Meeting all that apply to your project should give you the “perfect shear wall.” But ignoring some of them could mean that errors will work together to make your shear wall much less effective than the designer intended.

As an example, let’s say that our plans call for 3/8-inch sheathing with edge nailing at 4 inches to 2x studs using 8-penny common nails driven into Douglas Fir framing. What is built in the field uses 8-penny “cooler” nails (0.113-inch diameter, 2 3/8 inches long). Instead of Douglas Fir the sill is Hem-Fir, which is more commonly available than Douglas Fir as pressure-treated material (Hem-Fir accepts chemical treatment more easily than Douglas Fir).

The original design was based on a shear wall capacity of 350 pounds per foot (see the left-hand column for a “Type 4” wall in the Sample Shear Wall Schedule on Page 31). The deviations from the plans have the following effects:

Cooler nails at 4 inches in 3/8-inch sheathing have an allowable capacity of 245 pounds per foot (given in ICC Evaluation Service Report 153910, [ESR-1539], Table 17).

Hem-Fir lumber is not as dense as Douglas Fir. Nails in Hem-Fir give only 82 percent of the connection strength of nails in Douglas Fir (Footnote a in IBC Table 2306.3., the table that gives allowable shear wall capacities).

Now our wall strength is 245 pounds per foot multiplied by 82 percent, or (245 pounds per foot) x 0.82 = 201 pounds per foot.

We have reduced our wall strength from 350 pounds per foot to 201 pounds per foot. Our wall has lost over forty percent of its intended strength! What if we also had overdriven nails, thinner sheathing or nails spaced farther apart than specified on the plans? Field inspectors commonly find two or more such problems in the same shear wall.

Most of the above items will be discussed in more detail under the section titled, “Internal Strength—Making the Wall Strong Enough to Resist the Load” beginning on Page 48.

3.1.4 Special inspection of shear walls and related elements

The IBC now requires periodic special inspection for construction in high wind or earthquake classifications (IBC Sections 1706 and 1707). For wind, the requirements apply in Wind Exposure Category B where the 3-second gust basic wind speed is 120 mph or greater, or in Wind Exposure C or D where the 3-second gust basic wind speed is 110 mph or greater. For seismic the requirement applies to all construction for Seismic Design Categories C, D, E, or F. These wind and earthquake classifications cover virtually all of the west coast of the U.S., the Gulf Coast, and much of the east coast.

Special inspection requirements apply to “nailing, bolting, anchoring and other fastening of components within the main windforce- or seismic-force-resisting system, including wood shear walls, wood diaphragms, drag struts, braces, shear panels, and hold-downs” (IBC Sections 1706.2 and 1707.3)

A partial exception to this requirement applies if the sheathing nailing is spaced more than 4 inches apart and states that special inspection is not required for “wood shear walls, shear panels and diaphragms, including nailing, bolting, anchoring and other fastening to other components of the windforce- or seismic-force-resisting system”. Whether all the special inspection requirements are excluded is not entirely clear. Do drag struts, braces, and hold-downs
still require special inspection? There is some opportunity for local jurisdictions to interpret these requirements.

Designers should be aware of the above requirements and the exception to them, which leaves 6-inch edge nailing as the only option to eliminate special inspection costs. Designing with only this lighter nailing schedule limits the strength of shear walls considerably. Contemporary building designs often dictate the use of shear panel nailing at spacings much less than 6 inches.

### 3.1.5 Sample shear wall schedule

Your plans may include a shear wall schedule that calls out information such as sill anchor size and spacing, stud sizes, end-post sizes, tie-downs, framing connectors to fasten to framing below, shear panel thickness, nail size and spacing and other information relevant to the design. Note that shear wall schedules vary from one designer to another. A “Type 1” shear wall on one set of plans may be the same as a “Type 8” designated by another designer or a “Type E” by another.

The APA’s initial research listed strength values for five panel thicknesses, three sizes of nails and four edge-nailing spacings. Their table lists 48 different combinations for all these variables. The International Staple, Nail and Tool Association (ISANTA) had engineers calculate the theoretical strength of many different sized fasteners based on the 1991 *National Design Specification for Wood Construction*. These calculations are the basis for legacy National Evaluation Service Report 272 (NER-272), which has been replaced by ICC Evaluation Service Report 153910 (ESR-1539), which the model building codes accept as the allowable strengths for these fasteners. The results of these calculations make up approximately eight pages of tables and 540 entries for shear walls alone. Designers choose the panel thickness and nailing requirements from this huge selection to meet the needs of their projects. To make things even more complicated, the Special Design Provisions for Wind and Seismic (introduced with the 2009 IBC) give allowable shear values depending on whether the forces on the wall are generated by wind or earthquakes (strength values may be increased by 40 percent to resist wind forces). Furthermore, these values are adjusted according to whether the designer is using “allowable stress design” or “load and resistance factor design”. A sample shear wall schedule is shown on the following pages with some notes regarding shear wall construction. The shear values listed in the schedule depend on strict adherence to all of the Shear Wall Notes.
### SAMPLE SHEAR WALL SCHEDULE

(See Note 1)

<table>
<thead>
<tr>
<th>MAX. SHEAR* (lbs./ft.)</th>
<th>SYMBOL ON PLAN</th>
<th>SILL ANCHOR BOLTS (2, 4, 7, 8, 19)</th>
<th>MINIMUM SILL THICKNESS (3)</th>
<th>TIE-DOWN ANCHOR ROD (4, 5, 6)</th>
<th>MINIMUM END-POST TIE-DOWNS (4, 5)</th>
<th>SHEATHING (Plywood or OSB) (9, 10, 12, 13)</th>
<th>PANEL EDGE NAILING (14, 15, 16, 17 18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>180</td>
<td>1</td>
<td>( \frac{3}{8} ) @ 6' (18)</td>
<td>2x</td>
<td>N/A</td>
<td>Dbl. 2x</td>
<td>(Designer must select) ( \frac{3}{16} ) (11)</td>
<td>6d @ 6&quot;</td>
</tr>
<tr>
<td>200</td>
<td>2</td>
<td>( \frac{3}{8} ) @ 6'</td>
<td>2x</td>
<td>N/A</td>
<td>Dbl. 2x</td>
<td><em>tie-downs from locally</em> ( \frac{3}{8} ) (11)</td>
<td>6d @ 6&quot;</td>
</tr>
<tr>
<td>260</td>
<td>3</td>
<td>( \frac{3}{8} ) @ 6'</td>
<td>2x</td>
<td>( \frac{3}{8} ) x 15°</td>
<td>Dbl. 2x</td>
<td><em>available mfrs. or distributors</em>( \frac{3}{8} ) (11)</td>
<td>8d @ 6&quot;</td>
</tr>
<tr>
<td>350**</td>
<td>4</td>
<td>( \frac{3}{8} ) @ 4'</td>
<td>2x</td>
<td>( \frac{3}{8} ) x 15°</td>
<td>Dbl. 2x</td>
<td>( \frac{3}{8} ) (11)</td>
<td>8d @ 4&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SEE NOTE 3 (on the next page)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>490</td>
<td>5</td>
<td>( \frac{3}{8} ) @ 4'</td>
<td>3x</td>
<td>( \frac{3}{8} ) x 15°</td>
<td>4x</td>
<td>( \frac{3}{8} ) (11)</td>
<td>8d @ 3&quot;</td>
</tr>
<tr>
<td>600</td>
<td>6</td>
<td>( \frac{3}{8} ) @ 3'-4&quot;</td>
<td>3x</td>
<td>( \frac{3}{8} ) x 18&quot;</td>
<td>4x</td>
<td>( \frac{3}{32} )</td>
<td>10d @ 3&quot;</td>
</tr>
<tr>
<td>770</td>
<td>7</td>
<td>( \frac{3}{8} ) @ 2'-6&quot;</td>
<td>3x</td>
<td>( \frac{3}{8} ) x 18&quot;</td>
<td>4x</td>
<td>( \frac{3}{32} )</td>
<td>10d @ 2&quot;</td>
</tr>
<tr>
<td>870</td>
<td>8</td>
<td>( \frac{3}{8} ) @ 2'-3&quot;</td>
<td>3x</td>
<td>( \frac{3}{8} ) x 18&quot;</td>
<td>4x</td>
<td>( \frac{3}{32} ) or ( \frac{15}{32} ) Structural 1</td>
<td>10d @ 2&quot;</td>
</tr>
</tbody>
</table>

**Maximum shear is shown here for reference only. Values in the Shear Wall Schedule are based on Table 2306.3 from the 2009 IBC. Values listed above may be increased by 40% for wind loading per IBC Section 2306.3 These values are subject to revision. The IBC tables are based on testing done by APA—The Engineered Wood Association.**

**380 if 3x framing is used under all panel joints.**