

# Appendix B

## EARTHQUAKE PROVISIONS CHECKLIST FOR BUILDERS AND DESIGNERS

### General Earthquake-Resistance Requirements

#### Load Path

C   NC   N/A   Priority

**HIGH** Foundation anchor bolts. *IRC* Section R403.1.6 for all SDCs. *IRC* Section R403.1.6.1 and R602.11.1 for foundation anchor bolts and plate washers in SDCs D<sub>1</sub> and D<sub>2</sub> (and townhouses in SDC C).

Typical 1/2-inch diameter bolts at 6 feet along all exterior walls. Also, 1/2-inch bolts at 6 feet along interior braced walls and interior bearing walls supported on a continuous foundation, in SDCs D<sub>1</sub> and D<sub>2</sub> (and townhouses in SDC C); 1/2-inch at 4 feet along all exterior walls and along all interior bearing walls and interior bracing walls supported on a continuous foundation for three-story in SDC D<sub>1</sub> (and three-story townhouses in SDC C).

3x3x1/4-inch steel plate washers: On all required anchor bolts in SDCs D<sub>1</sub> and D<sub>2</sub> (and townhouses in SDC C).

First anchor bolt should be placed seven bolt diameters minimum (3-1/2 inches for 1/2-inch diameter, 4-1/2 inches for 5/8-inch diameter) and 12 inches maximum from each end of a foundation sill plate.

Sheathing and framing fasteners (except for 1/2-diameter or larger steel bolts) used in pressure preservatively treated wood framing members must have corrosion-resistant coating or be of corrosion-resistant material.

**HIGH** Overturning Anchorage. *IRC* Section R602.10.6 for alternate braced wall panels, all SDCs. *IRC* Section R602.10.11, second paragraph, Exception 2, where braced wall panels are not located at corners in SDCs D<sub>1</sub> and D<sub>2</sub>. *IRC* Section R703.7, Exceptions 3 and 4, when veneer is used in SDCs D<sub>1</sub> and D<sub>2</sub>. Overturning load path to foundation needed where hold-down anchors are used.

**Load Path Above-code Recommendations:**

- **Provide 4-foot anchor bolt spacing along all exterior and interior braced wall lines for two-story houses in SDCs D<sub>1</sub> and D<sub>2</sub>.**
- **Provide continuous foundation below interior braced walls with anchor bolts at spacing of 6 feet or less in all SDCs.**
- **Provide corrosion-resistant coatings for anchor bolts installed through pressure preservative treated foundation sill plates in all SDCs.**
- **Do not “wet set” anchor bolts; securely place anchor bolts prior to placing concrete.**
- **In SDC C, provide overturning anchorage as required in SDCs D<sub>1</sub> and D<sub>2</sub> for braced wall panels not located at corners and for houses with masonry veneer.**
- **Add tie straps between first and second story corner studs to tie the walls together in SDCs C, D<sub>1</sub> and D<sub>2</sub>.**
- **Use oversized sheathing panels on exterior walls and lap over rim-joint. Nail both into the plates (top and bottom) and the rim-joists in all SDCs.**

**MED** Minimum fastening. All SDCs per *IRC* Table R602.3.

**MED** Designed collector members aligned with and connected to the top plate of braced walls (continuous from the end of a braced wall line to the end of the braced wall panel closest to the end of the wall line). In all SDCs where the first braced wall panel begins more than 12 feet from the end of a braced wall line. (Section *IRC* R602.10.1)

Also, in SDCs D<sub>1</sub> and D<sub>2</sub>, where the braced wall panel uses wood structural panel sheathing and is not located at the end of the wall line. However, when either (a) a minimum 24-inch-wide panel is provided each side of the wall corner or (b) the braced panel end closest to the corner is provide with a hold-down, a designed collector is not required if the wood structural panel braced wall panel is located 8 feet or less from the end of the braced wall line. (*IRC* Section R602.10.11 last paragraph)

## Foundations and Foundation Walls

### Concrete Foundations

**C NC N/A Priority**

- HIGH** Horizontal reinforcing. In SDCs D<sub>1</sub> and D<sub>2</sub>, typical one No.4 in footing. Additional No. 4 in concrete stem wall (if stem wall occurs). One No. 4 top and bottom in thickened slab footing, with alternate of one No. 5 or two No. 4 in middle third of footing height for thickened slab footings cast monolithically with slab. (*IRC* Sections R403.1.3 through R403.1.3.2)
- HIGH** Vertical reinforcing. In SDCs D<sub>1</sub> and D<sub>2</sub>, one No. 4 at 48 inches maximum spacing where a pour joint occurs between concrete footing and concrete stem wall. (*IRC* Section R403.1.3)
- MED** Adequate support of reinforcing and anchor bolts. Reinforcing concrete cover distances of 3 inches when cast against earth and 1-1/2 inches when concrete will be exposed to weather.
- HIGH** Clean footing excavations before casting concrete. Proper concrete consolidation. No water added to concrete mix at site.
- MED** Minimum concrete strength. 2500 psi, all SDCs. 3000 or 3500 psi in moderate or severe weathering probability areas (*IRC* Section R402.2 and Table R402.2).
- MED** Rebar lap splice length of 24-inches (straight lap) (*IRC* Section R611.7.1.2). Rebar bend radius (outer) of 2 inches for No. 4 and 2-1/2 inches for No. 5. Hook at corners and intersections of 8 inches for No. 4 and 10 inches for No. 5.

### Masonry Foundations

**C NC N/A**

- HIGH** Horizontal reinforcing.
- HIGH** Vertical reinforcing.
- MED** Rebar lap splice length of 24-inch (straight lap) (*IRC* Section R606.11.2.2.3). Rebar bend radius (outer) of 2 inches for No. 4 and 2-1/2 inches for No. 5. Hook at corners and intersections of 8 inches for No. 4 and 10 inches for No. 5 (*IRC* Section R606.11.7.4).

### Foundation Walls

**C NC N/A**

- HIGH** Wall thickness.
- HIGH** Horizontal reinforcing.
- HIGH** Vertical reinforcing.

- MED** Rebar lap splice length of 24-inches (straight lap). Rebar bend radius (outer) of 2 inches for No. 4 and 2-1/2 inches for No. 5. Hook at corners and intersections of 8 inches for No. 4 and 10 inches for No. 5

**Above-code Recommendations:**

- **Avoid construction of slab on grade homes on cut and fill sites where possible. Where this condition cannot be avoided, provide additional quality control for fill placement and compaction operations.**
- **Regardless of SDC, provide not less than one continuous horizontal No. 4 reinforcing bar in concrete footings. Provide a second No. 4 horizontal bar in stem wall if occurs. This will provide tension and bending capacity to help mitigate foundation damage due to earthquake, wind, soil movement and frost heave.**
- **Regardless of SDC, remove loose debris in the construction joint between a concrete footing and a separately cast slab-on-grade.**
- **In SDCs C, D1 and D2, provide not less than No. 4 at 4-foot vertical bars as dowels between a concrete footing and a separately cast slab on grade.**
- **Regardless of SDC, provide not less than one continuous No. 4 reinforcing bar in masonry foundations.**

**Floor Construction**

C NC N/A

- HIGH** Floor sheathing nailing. Floor sheathing should be edge nailed to blocking above all braced wall lines, exterior and interior, as part of the load path (*IRC* Table R602.3(1), Footnote i). Blocking with edge nailing needs to have a load path to top of braced wall panels.
- MED** SDCs D<sub>1</sub> and D<sub>2</sub>, blocking or lateral restraint. Required at intermediate floor framing member supports. (*IRC* Section R502.7, Exception)

**Light-Frame Wall Construction**

- HIGH** Overdriven sheathing nails. For wood structural panel sheathing, nails are to be driven so that the top of the head is flush with the face of the sheathing. (It is recommended that where nail heads occasionally are more than 1/16-inch below the surface, an additional nail should be provided between existing nails. If a substantial number of nails are overdriven, the sheathing should be removed and the framing checked for splitting before replacing the sheathing with proper nails.)

- HIGH** Sheathing nailing to hold-down posts and studs. Hold-downs cannot carry any load unless the wall sheathing is edge-nailed to the hold-down post or stud.
- HIGH** Threaded rods with properly attached nuts need to be in place before the wall sheathing is attached to the second side of the walls.

**Above-code Recommendations:**

- **Increase first-story strength and stiffness to mitigate weak-story irregularity. Approaches include: (a) use of wood structural panel wall bracing and hold-down connectors at each end of each full height wall segment, (b) fully sheathing all exterior walls including below windows and above and below doors and providing hold-down connectors at building corners, and (c) providing more than the minimum braced wall panel length.**
- **Increase cripple wall strength and stiffness to mitigate weak-story irregularity by sheathing full length of exterior cripple walls.**
- **Use oversized sheathing panels on exterior walls to increase wall stiffness and strength. Lap the sheathing over the floor joists and nail to both the plates (top and bottom) and the floor joists.**

**Roof Construction**

C NC N/A

- HIGH** Sheathing nailing at braced wall lines. Roof sheathing should be edge nailed (to blocking where present) above all braced wall lines, exterior and interior, as part of the load path (*IRC* Table R602.3(1), Footnote i). Blocking with edge nailing needs to be nailed to the top of the braced wall below to provide a complete load path.

**Cold-formed Steel Construction**

C NC N/A

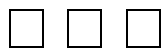
- HIGH** Load path connections. Connection of cold-formed steel framing members is different than wood light-frame connection. The *IRC* provisions include a significant number of specific connection details. Attention to these details is important to the building performance for all load types.

**Above-code Recommendations:**

- **Add interior cold-formed steel braced walls such that the distance between braced wall lines does not exceed 35 feet.**
- **In all SDCs, apply the irregularity limitations developed for wood light-frame houses (IRC Section R301.2.2.2.2).**

**Masonry Wall Buildings**

C NC N/A



**HIGH** Construction quality control. Proper type of mortar for masonry being used and proper mortar mixing. (Type N mortar is prohibited in higher SDCs.) Proper placement of reinforcing. Adequate support and attachment of reinforcing and anchor bolts. Cleaning out of grout space to allow proper grout placement, including cleaning out excess mortar if necessary. Provide cleanouts if necessary for adequate cleaning. Consolidation of grout.

**Above-code Recommendations:**

- **Each exterior wall and each interior braced wall should have one, and preferably two, sections of solid wall not less than 4 feet in length.**
- **Sections of solid wall should be spaced no more than 40 feet on center and should be placed as symmetrically as possible.**
- **All masonry walls should be supported on substantial continuous footings extended to a depth that provides competent bearing.**
- **The distribution of interior masonry braced walls should be carefully balanced and floor and roof plans should use simple rectangular shapes without jogs and openings.**
- **Apply the irregularity limitations developed for wood light-frame houses (IRC Section R 301.2.2.2.2). The IRC exceptions to Irregularities 2 and 5 can be applied but the rest of the exceptions are not applicable.**
- **Solid portions of wall should be stocked from floor to floor and masonry walls should be continuous from the top of the structure to the foundation. Masonry walls not directly supported on walls below require engineered design for gravity load support and design for earthquake and wind loads should be provided.**
- **Running board lay up of masonry units should be used instead of stack bond lay up.**

**Above-code Recommendations (continued):**

- For concrete masonry, use open end units at locations of vertical reinforcement and use wood beam units for horizontal reinforcing to increase the interlocking of masonry construction.
- Apply the measures required or recommended for masonry construction in areas of high earthquake risk, in areas of lower earthquake risk, and in high-wind areas. Priorities include provisions for reinforcing (*IRC* Figure R606.10 (2)), wall anchorage using details developed to resist out-of-plane wall loads (e.g., *IRC* Figures R611.8 (1) through (7)), minimum length of bracing walls, and a spacing limit for braced wall lines.

**Concrete and Insulating Concrete Form Wall Buildings**

C NC N/A

- HIGH** Construction quality control. Proper placement of reinforcing. Adequate support and attachment of reinforcing and anchor bolts. Cleaning out of cells space to allow proper concrete placement. Consolidation of concrete.

**Above-code Recommendations:**

- Carefully balance bracing walls around the perimeter of the building.
- Apply the measures required or recommended for ICF houses in areas of high earthquake risk, in areas of lower earthquake risk, and in high-wind areas. Priorities include wall anchorage using details developed to resist out-of-place wall loads (e.g., *IRC* Figures R611.8 (2) through (7)).

**Stone and Masonry Veneer**

C NC N/A

- HIGH** Veneer thickness limited to 5-inch nominal thickness in SDCs A, B, and C, 4-inch nominal thickness in SDC D<sub>1</sub>, and 3-inch actual thickness in SDC D<sub>2</sub> except that up to 5-inch nominal thickness can be used in SDC D<sub>1</sub> and D<sub>2</sub> if veneer only extends to first story above grade. (*IRC* Section R703.7)

**Above-code Recommendations:**

- **Use corrosion-resistant sheet metal ties or wires to fasten veneer. The ties or wires should penetrate the house paper and sheathing and should be embedded in the wall studs.**
- **Where veneer can be used only on the first story above grade, increase the length of the structural wood panel bracing and use hold-down devices on braced wall panels in the first story.**

### Fireplaces and Chimneys

**C NC N/A**

**HIGH** Masonry reinforcing. Vertical reinforcing of not less than four No. 4 bars for chimneys up to 40 x 24 inches. Should extend from bottom of foundation (3-inch minimum concrete cover) to top of chimney except that splices of not less than 24 inches are acceptable. Must be placed such that reinforcing can be surrounded in grout. Horizontal ties of 1/4-inch minimum at 18 inches maximum on center in mortar joint. SDCs D<sub>1</sub> and D<sub>2</sub>. (*IRC Section R1003.3*)