

## Appendix A

### ANALYSIS OF THE MODEL HOUSE USED IN THIS GUIDE

A model single-family detached house was developed and analyzed in preparing this guide. The house is described in Chapter 1, and the results of the analysis are referred to throughout the guide. This appendix provides additional details concerning the model house, the analysis, and the interpretation of analysis results.

The analysis of the model house provided an approximate comparison of performance for varying wood light-frame house and bracing configurations permitted by the *IRC* and permitted the assessment of improved performance resulting from application of the **above-code** recommendations made in this guide. While the model house and the analysis performed cannot represent all houses that may be constructed using *IRC* provisions, they do provide a specific example of relative performance from which trends can be observed.

#### A1 MODEL HOUSE

The model house contained both one-story and two-story portions, three bedrooms, 2-1/2 baths, and an area of approximately 2,500 square feet plus garage. The house design is intended to reflect current configurations for wood light-frame construction but not necessarily any specific region of the United States. Separate analytical models were developed for common variations in the design including base conditions, exterior finishes, and earthquake bracing configurations.

The base conditions are slab-on-grade construction with turned-down footings (Figure A-1), continuous exterior footings with level 2-foot-high cripple walls (Figure A-2), a hillside condition with cripple walls of varying height (Figure A-3), and a full basement with concrete or masonry walls (Figure A-4). Exterior finishes are categorized as light and veneer. The light finish is intended to represent low-weight finishes such as vinyl or fiber-cement board siding. The veneer is intended to represent a single-wythe anchored brick veneer used for the entire house exterior. Bracing requirements were determined for each configuration and Seismic Design Category (SDC) in accordance with the 2003 *IRC*. Chimneys of light-frame construction were used for all house configurations.



Figure A-1 Slab on grade base.



Figure A-2 Level cripple wall base.

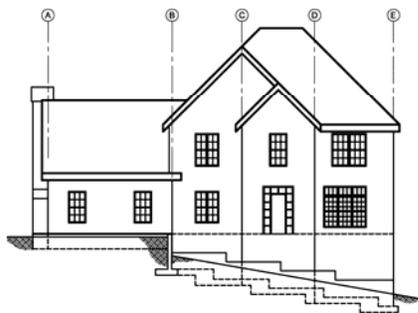


Figure A-3 Hillside base.

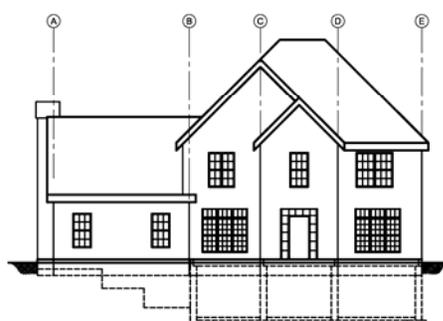


Figure A-4 Basement.

*IRC* prescriptive bracing requirements were determined for each combination of base condition, exterior finish, and Seismic Design Category. Because use of veneer is not permitted on houses with cripple walls in SDC D<sub>1</sub> and D<sub>2</sub> (*IRC* Section R703.7, Exceptions 3 and 4), both the level and hillside cripple wall configurations with veneer were limited to SDC C. Table A-1 is an example of one bracing spreadsheet. The remaining spreadsheets used in determining bracing requirements for each of the designs are not included here due to their length; however, they and other information used in the analysis are available upon request from the Building Seismic Safety Council.

Because gypsum wallboard is used in almost every U.S. residential building, it was used for the structural bracing wherever possible. Since it would be installed as a finish anyway, its use for bracing has the least construction cost. Wood structural panel wall bracing was used where length and percentage bracing requirements could not be met with gypsum wallboard. Alternative braced wall panels conforming to *IRC* Section R602.10.6 were used for the slender walls at the house front and garage front for slab-on-grade and basement base conditions. The alternative braced wall panels require support directly on a continuous foundation; therefore, they could not be used in combination with cripple walls. The *IRC* Section R602.10.5

“continuous structural panel sheathing” modifications to bracing length and percent were not used. See Figure 5-6a through 5-6b for an example bracing plan of a cripple wall base condition in SDC C.

Several interpretations of *IRC* requirements were made in developing the bracing designs. First, it was recognized that the roof-plus-ceiling assembly weight would fall just below the limit of 15 psf of *IRC* Section R301.2.2.2.1 if the roof assembly weight were considered based on the unit weight on slope (12:12 roof slope) but would exceed 15 psf if the weight were adjusted to horizontal projected area. Although adjustment to the horizontal projected area is common practice in engineering calculations, it was decided that this calculation is not specifically noted in the 2003 *IRC* provisions so the roof-plus-ceiling assembly weight was deemed to fall within the 15 psf *IRC* limit.

The second interpretation related to the use of gypsum wallboard bracing (*IRC* Section R602.10.3, Method 5). *IRC* Section R602.10.4 requires that gypsum wallboard braced wall panels applied to one side of a wall be at least 8 feet in width. It was interpreted to mean that a continuous length of full-height wall not less than 8 feet wide would have to be available in order to use this bracing method. Interruption of the 8-foot length by perpendicular walls was interpreted to mean that it was not permitted. Where an 8-foot length of full-height wall was not available, wood structural panels were used as bracing instead. Based on this interpretation and the configuration of the model house, wood structural panels rather than gypsum wallboard were used for a significant portion of the exterior wall bracing. Where gypsum wallboard bracing can be applied to both faces of a wall (such as at interior walls), the minimum required length of full-height sheathing is reduced to 4 feet. While the perforated shear wall method that includes hold-down anchorage at the ends of the wall line was used as an **above-code** option for the analysis, the continuous sheathed option of *IRC* Section R602.10.5 that allows a 10 percent reduction in the sheathing percentage was not used in the analysis.

The third interpretation relates to the bracing requirements used for the model house in SDC C. *IRC* Table R602.10.1 specifically identifies sheathing length requirements for SDC C. Some *IRC* users, however, interpret the *IRC* Section R301.2.2 exception to mean that the table bracing length requirements for SDCs A and B can be used for houses in SDC C. Analysis of the model house performed for this guide used the SDC C bracing length requirements.

The resulting bracing configurations are illustrated on a set of bracing plans and elevations for each of the designs are available from the Building Seismic Safety Council on a CD-ROM. The increased bracing length requirements for higher Seismic Design Categories can be observed to have reduced allowable door and window openings.

**Table A-1 Example Wall Bracing per 2003 IRC, Slab-on-grade Base Condition**

Seismic Design Category	Wall Finish	Total Stories	Story Considered	Wall Line	Wall Line Length (ft)	Type 3 Percent	Type 3 Length (ft)	Other Type Percent	Other Type Length (ft)	Adjustments				Type 3 Adjusted Length (ft)	Other Type Adjusted Length (ft)
										Wall Line Spacing R602.10.1.1	Wall Wt. Table R602.10.3 Footnote d (1)	Roof + Ceil. Table R301.2.2.4	Veneer R703.7 Exc. 2		
C	light	2	2	B	33.5	16	5.4	25	8.4	1.06	0.85	1.00	1.00	4.8	7.5
			2	E	30	16	4.8	25	7.5	1.06	1.00	1.00	1.00	5.1	7.9
			2	1,7	37	16	5.9	25	9.3	1.00	1.00	1.00	1.00	5.9	9.3
			2	5,6	37	16	5.9	25	9.3	1.00	1.00	1.00	1.00	5.9	9.3
		1 (2)	1	A	40	16	6.4	25	10.0	1.00	1.00	1.00	1.00	6.4	10.0
			1	1	20	16	3.2	25	5.0	1.14	1.00	1.00	1.00	3.7	5.7
			1	8	20	16	3.2	25	5.0	1.14	1.00	1.00	1.00	3.7	5.7
			1	B	40	30	12.0	45	18.0	1.06	0.85	1.00	1.00	10.8	16.2
		2	1	E	29	30	8.7	45	13.1	1.06	0.85	1.00	1.00	7.8	11.7
			1	2	37	30	11.1	45	16.7	1.00	0.85	1.00	1.00	9.4	14.2
			1	5,6	37	30	11.1	45	16.7	1.00	0.85	1.00	1.00	9.4	14.2
			1	5,6	37	30	11.1	45	16.7	1.00	0.85	1.00	1.00	9.4	14.2
C	veneer	2	2	B	33.5	16	5.4	25	8.4	1.06	1.00	1.00	1.00	5.7	8.9
			2	E	30	16	4.8	25	7.5	1.06	1.00	1.00	1.00	5.1	7.9
			2	1,7	37	16	5.9	25	9.3	1.00	1.00	1.00	1.00	5.9	9.3
			2	5,6	37	16	5.9	25	9.3	1.00	1.00	1.00	1.00	5.9	9.3
		1 (2)	1	A	40	16	6.4	25	10.0	1.00	1.00	1.00	1.00	6.4	10.0
			1	1	20	16	3.2	25	5.0	1.14	1.00	1.00	1.00	3.7	5.7
			1	8	20	16	3.2	25	5.0	1.14	1.00	1.00	1.00	3.7	5.7
			1	B	40	30	12.0	45	18.0	1.06	1.00	1.00	1.50	19.0	28.5
		2	1	E	29	30	8.7	45	13.1	1.06	1.00	1.00	1.50	13.8	20.7
			1	2	37	30	11.1	45	16.7	1.00	1.00	1.00	1.50	16.7	25.0
			1	5,6,7	37	30	11.1	45	16.7	1.00	1.00	1.00	1.50	16.7	25.0
			1	5,6,7	37	30	11.1	45	16.7	1.00	1.00	1.00	1.50	16.7	25.0

<sup>1</sup>Reduction cannot be applied to top-most story where resulting bracing length would be less than required for wind.

<sup>2</sup>The garage and family room areas are treated as a one-story building attached to the two-story house.

## **A2 ANALYSIS USING STANDARD ENGINEERED DESIGN METHODS**

Prior to evaluation using other methods, earthquake forces and deformations were estimated using the linear static methods commonly used in engineering design of new buildings. Included were force calculations using the *International Building Code (IBC)* linear static method, estimation of drift using the APA-The Engineered Wood Association four-term shear wall deflection equations at strength level forces, and amplification to estimated drifts using *IBC* amplification factors. This approach resulted in the APA shear wall deflection equations being used outside of their intended range (based on force per nail limits included with nail slip variables). This provided clearly unrealistic shear wall deflections amplified to unrealistic estimated drifts (over 36 inch drifts in some cases). Thus, it was concluded that the use of these engineered design estimates as predictors of performance for non-engineered buildings was not realistic and it was not pursued. Likewise, use of other available deflection equations that represent simplifications of the APA equations were not pursued. This issue should not occur when using this standard deflection calculation method for engineered buildings.

## **A3 ANALYSIS USING NONLINEAR METHODS**

Nonlinear time-history analysis using the Seismic Analysis of Woodframe Structures (SAWS) analysis program was chosen as the best available method for estimating force and deformation demands based on analytical studies that were verified against shake table results from the FEMA-funded CUREE-Caltech Woodframe Project. Analysis models included both designated bracing and finish materials. The Woodframe Project analytically predicted forces and deflections compared favorably with shake-table results and were clearly differentiated from analysis and testing results without finish materials (Folz and Filiatrault, 2002).

The SAWS analysis program uses rigid diaphragms to represent floor and roof diaphragms. Walls are modeled as nonlinear springs with hysteretic parameters developed specifically to describe the behavior of woodframe bracing systems. For the example house, rigid diaphragms were used to represent the high roof, the low roof plus second floor, and, where appropriate, the first floor. A simplified representation of the rigid diaphragms and wall springs for the model house is presented in Figure A-5.

Ten sets of hysteretic parameters were developed from component testing data to describe wall bracing and interior gypsum wallboard finishes. Figure A-6 illustrates the meaning of the parameters, and a summary of analytical modeling parameter values is provided in Table A-2. For each of the bracing materials (with the exception of No. 5 and 6), the hysteretic parameters were determined for a 4-foot bracing length. Because widely varying lengths are used in the house, the parameters were scaled for varying bracing lengths.

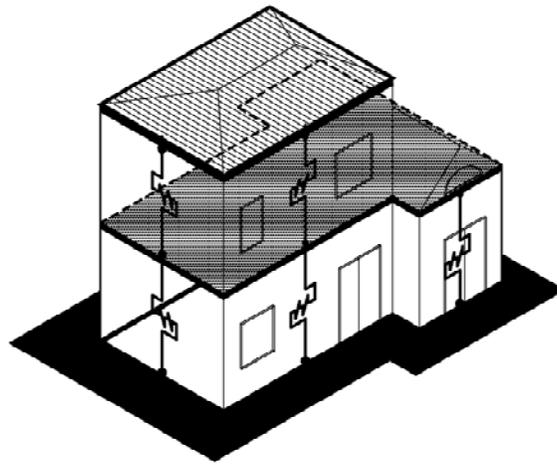


Figure A-5 Analysis model.

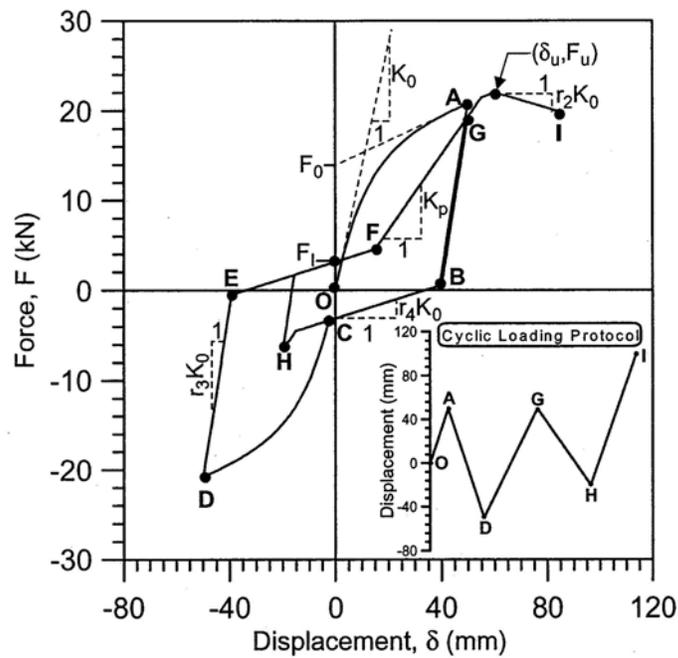


Figure A-6 Hysteretic parameters for model ((Folz and Filiatrault, 2002).

Hysteretic parameters currently available from laboratory testing of wall components vary based on wall boundary conditions, test set-up, and test protocol. Parameters chosen for the analysis of

the model house tended towards lower bounds of strength and stiffness. Future analytical studies should consider exploring upper and lower bounds.

In order to simplify interpretation of analysis results, the analysis model uses consistent identification of bracing walls across all building configurations. Because of this modeling approach, cripple walls have been included in the model for all building configurations; where slab-on-grade construction occurs, the cripple walls are modeled as extremely rigid elements (Property No. 9) resulting in negligible deflection. In addition, some wall elements occur only in limited configurations; a bracing length of 0.1 foot is used where a bracing panel is intended to have no effect.

**Table A-2 Hysteretic Parameters Used for Nonlinear Dynamic Model**

Property No.	Use	Fo (k)	Fi (k)	$\Delta_u$ (in)	So (Ko) (k/in)	r1	r2	r3	r4	alpha	beta	$\Delta_{CUREE}$ (in)	Fu
<b>Basic Model Properties</b>													
3	gypsum wallboard lower bound <sup>1</sup>	0.50	0.20	0.70	3.0	0.130	-0.050	1.000	0.030	0.40	1.10	0.80	0.47
4	4 ft OSB w/o tie-down	0.59	0.15	1.00	2.8	0.096	-0.021	1.000	0.010	0.40	1.10	1.90	0.63
5	2'-8" wall one-sided	1.20	0.20	2.70	3.0	0.020	-0.100	1.000	0.024	0.87	1.10	2.00	0.62
6	2'-8" wall two-sided	2.40	0.40	2.70	6.0	0.020	-0.100	1.000	0.024	0.87	1.10	2.00	1.24
7	2 ft high cripple wall <sup>1</sup>	3.00	0.30	1.00	20.0	0.010	-0.050	1.000	0.010	0.87	1.10	1.00	3.20
8	1:3 stepped cripple wall <sup>1</sup>	3.30	0.60	1.00	23.0	0.090	-0.110	1.000	0.040	0.87	1.10	0.90	5.48
9	zero height cripple wall = 100 x No. 7	300.00	30.00	1.00	2000.0	0.010	-0.050	1.000	0.010	0.87	1.10	1.00	320.00
<b>Code Plus Properties</b>													
10	Code Plus fully sheathed perforated shear wall <sup>1</sup>	2.30	0.05	2.20	2.6	0.200	-1.000	1.000	0.020	0.87	1.10	1.50	3.00
11	4 ft OSB w/ tie-down	1.70	0.50	3.00	6.8	0.040	-0.056	1.000	0.024	0.87	1.10	2.60	2.51
12													

<sup>1</sup>Values in table are for 4 ft length. Fo, Fi & Ko in model are scaled by length of full height sheathing. See separate spreadsheets.

The strength and stiffness contribution of exterior wall finishes was not included in the analysis. This approach was chosen because it would lead to a lower bound and, therefore, conservative estimate of deformation demand. In addition, some exterior finish materials are believed to have very little impact on building behavior (e.g., vinyl siding) and information was not available on the contribution of some other finishes (e.g., brick veneer). Due to the judgment necessary to select appropriate component testing and to derive parameters and the simplification of not including exterior finishes, the resulting modeling must be qualified as being approximate.

Earthquake demand is represented using the larger horizontal acceleration record from Canoga Park for the 1994 Northridge, California, earthquake. This record was chosen because it corresponds well with the code design spectra over a range of building periods. The peak acceleration was scaled for each Seismic Design Category by dividing the maximum  $S_{DS}$  value for each category by 2.5, resulting in peak accelerations of 0.2, 0.33 and 0.47g for SDCs C, D<sub>1</sub>, and D<sub>2</sub>, respectively. For comparison, the recorded ground motion has a peak acceleration of

0.42g and was scaled to 0.50g to represent Zone 4 anticipated ground motions in the CUREE shake-table testing. The ground motion scaling used for this analysis represents the demand used as a basis for code design. The demand from the maximum considered earthquake (MCE) ground motion (MCE) would be approximately 50 percent greater.

Detailed assembly weights and building weights have been determined for each house configuration. The analysis model spreads the resulting mass uniformly over a single rectangle used to describe each above-ground diaphragm. The center of the mass rectangle is set at the calculated center of mass of the building. This simplification, made necessary by analysis limitations, should have a minor effect on results.

## A4 ANALYSIS RESULTS

The selected ground motion was run once in the horizontal X-direction and once in the horizontal Y-direction for each combination of base condition, exterior finish, and Seismic Design Category as well as for a series of **above-code** recommendations. From the nonlinear time-history analysis, peak drifts in each of the bracing wall lines and peak reactions to supporting foundations were extracted and summarized in tables. These tables are not included here for brevity but are available upon request from the Building Seismic Safety Council on the analysis CD. The “controlling” value was the largest absolute value of the X- and Y-directions.

### A4.1 Deformation Demand Relation to Performance

In order to translate the results of the analysis into an approximation of house performance, three ranges of peak transient wall drift and associated approximate descriptions of building performance were developed. The choice of range and description of performance are based on component and full-building test results combined with the opinions of those participating in the development of this guide.

The approximate performance categories and corresponding drift ranges are:

- **Minor** damage potential – Less than or equal to 0.5% story drift

The house is assumed to suffer minor nonstructural damage such as cracked plaster or gypsum wallboard and hopefully would be “green-tagged” (occupancy not limited) by inspectors after an earthquake, which would permit immediate occupancy. Some repairs should still be anticipated.

- **Moderate** damage potential – Above 0.5% to 1.5% story drift

The house is assumed to suffer moderate damage including possible significant damage to materials and associated structural damage, but the building is assumed to have some reserve capacity in terms of strength and displacement capacity. The house hopefully would be “green-tagged” or,

more likely, “yellow-tagged” (limited occupancy) by inspectors after an earthquake and may or may not be habitable. Significant repairs should be anticipated.

- **Significant** damage potential – Greater than 1.5% story drift

The house is assumed to have significant structural and nonstructural damage that could result in its being “red-tagged” (occupancy prohibited) by inspectors after an earthquake. Significant repairs to most components of the building should be anticipated, and it may be more economical to replace the house rather than repair it.

Use of these three categories permits an approximate comparison of the relative performance of different *IRC* bracing solutions and **above-code** recommendations.

#### A4.2 Discussion of Results

Selected results of peak drift values and approximate performance category are provided in Tables A-3 and A-4. In most cases, the drift increased with increased SDC in spite of the bracing requirements also having increased. The approximate performance often increased from minor or moderate to significant as the SDC went from C to D<sub>2</sub>. The primary reason is the inclusion of interior gypsum wallboard in the models for all Seismic Design Categories. As the SDC increased, interior walls became required braced wall panels per *IRC* requirements rather than simply nonstructural partition walls; however, the analytical model did not change because the interior walls had already been included. The result was application of a higher demand to a model with only nominal increases in resistance.

**Table A-3 Selected Results for *IRC* Bracing Provisions, Slab-on-grade Base Condition**

Walls	Seismic Design Category	1st Story Peak Drift (in.) and Approximate Performance
Light	C	0.46 <b>Minor</b>
Light	D <sub>1</sub>	1.02 <b>Moderate</b>
Light	D <sub>2</sub>	1.72 <b>Significant</b>
Veneer	C	1.29 <b>Moderate</b>
Veneer	D <sub>1</sub>	1.34 <b>Moderate</b>
Veneer	D <sub>2</sub>	2.21 <b>Significant</b>

Although the building mass increased significantly with the addition of brick veneer, the increase in drift ranged from moderate to slight. This is due to the *IRC* requirement for wood structural panel sheathing and hold-down devices for veneer in SDCs D<sub>1</sub> and D<sub>2</sub>. The analysis model differentiated between wood structural panel shear walls with and without hold-down devices so the different strength, stiffness, and deformation capacity were accounted for. Because of this, the *IRC* bracing required for brick veneer was seen to partially compensate for the increased demand.

The **above-code** measures were applied to the slab-on-grade base condition. The measures were seen to generally reduce the building drift, although drift increases were seen in a few walls due to changes in diaphragm rotation. In SDC D<sub>2</sub>, the approximate performance was improved by one category for all three **above-code** measures. In SDCs C and D<sub>1</sub>, significant decreases in drift were seen within an approximate performance category.

**Table A-4 Selected Results for Above-code Measures, Slab-on-grade Base Condition**

Above-code Recommendation	Walls	1 <sup>st</sup> Story Peak Drift (in.), Approximate Performance, and Maximum 1 <sup>st</sup> Story Drift Reduction		
		SDC C	SDC D <sub>1</sub>	SDC D <sub>2</sub>
Original Code Minimum	Light	0.5 Minor Damage	1.0 Moderate Damage	1.7 Significant Damage
Above-code Continuous Sheathing	Light	0.3 Minor Damage 39 percent	0.7 Moderate Damage 42 percent	1.2 Moderate Damage 30 percent
Above-code Hold-downs	Light	0.5 Minor Damage 28 percent	0.9 Moderate Damage 36 percent	1.0 Moderate Damage 47 percent
Above-code Lap on Rim Joist	Light	0.5 Minor Damage 6 percent	1.0 Moderate Damage 7 percent	1.4 Moderate Damage 24 percent

The cost of implementing each **above-code** measure during construction of the house was estimated in terms of percentage change to the construction cost for the basic house structure. Comparison to total house cost was not made because variations in finishes and fixtures can dramatically vary the house cost.

Use of continuous wood structural panel wall sheathing (fully sheathed) with overturning anchors in the corners of the house significantly reduced the drift in all Seismic Design Categories, and the approximate performance category was increased by one in SDC D<sub>2</sub>. The cost of making this change was estimated to be 9 to 10 percent of the cost of the structural portion of the model house used in this guide.

The addition of hold-down anchors at the ends of each full-height wall segment (at the corners and edges of each door and window) significantly reduced the drift in all Seismic Design

Categories, and the approximate performance category was increased by one step in SDC D<sub>2</sub>. For the model house, the cost of implementing this improvement was estimated to be 18 percent of the structural cost of the house.

Lapping wood structural panel wall sheathing over the band joist of the floors did not have a significant effect in SDC C or D<sub>1</sub> but did improve the approximate performance category by one in SDC D<sub>2</sub>. The cost of implementing this improvement was estimated to be 0.5 percent of the cost of the structural portion of the house. This **above-code** measure can be accomplished by either sheathing the wall with oversized panels (9-foot panels on an 8-foot wall) or cutting and blocking standard size sheets.

Use of the **above-code** measures in combination is thought to have a cumulative effect in improving performance and so is encouraged.



# Appendix B

## EARTHQUAKE PROVISIONS CHECKLIST FOR BUILDERS AND DESIGNERS

### General Earthquake-Resistance Requirements

#### Load Path

**C** **NC** **N/A** **Priority**

- |  |   |
|--|---|
| <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | <p><b>HIGH</b> Foundation anchor bolts. <i>IRC</i> Section R403.1.6 for all SDCs. <i>IRC</i> 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).</p> <p>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).</p> <p>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).</p> <p>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.</p> <p>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.</p> |
| <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | <p><b>HIGH</b> Overturning Anchorage. <i>IRC</i> Section R602.10.6 for alternate braced wall panels, all SDCs. <i>IRC</i> 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>. <i>IRC</i> 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.</p>  |

**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**

- |                          |                          |                          |   |
|--------------------------|--------------------------|--------------------------|---|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>HIGH</b> 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. ( <i>IRC</i> Sections R403.1.3 through R403.1.3.2) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>HIGH</b> 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. ( <i>IRC</i> Section R403.1.3)  |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>MED</b> 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.  |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>HIGH</b> Clean footing excavations before casting concrete. Proper concrete consolidation. No water added to concrete mix at site.   |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>MED</b> Minimum concrete strength. 2500 psi, all SDCs. 3000 or 3500 psi in moderate or severe weathering probability areas ( <i>IRC</i> Section R402.2 and Table R402.2).  |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>MED</b> Rebar lap splice length of 24-inches (straight lap) ( <i>IRC</i> 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**

- |                          |                          |                          |  |
|--------------------------|--------------------------|--------------------------|--|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>HIGH</b> Horizontal reinforcing.  |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>HIGH</b> Vertical reinforcing.  |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>MED</b> Rebar lap splice length of 24-inch (straight lap) ( <i>IRC</i> 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 ( <i>IRC</i> Section R606.11.7.4). |

### Foundation Walls

**C NC N/A**

- |                          |                          |                          |                                     |
|--------------------------|--------------------------|--------------------------|-------------------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>HIGH</b> Wall thickness.         |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>HIGH</b> Horizontal reinforcing. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>HIGH</b> 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

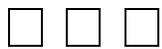
- HIGH** Load path connections. Connection of cold-formed steel framing members is different than wood light-frame connection. The *IRC* provisions include a significant number of specific connection details. Attention to these details is important to the building performance for all load types.

**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*)

## Appendix C

# EARTHQUAKE PROVISIONS CHECKLIST FOR DESIGNERS AND PLAN CHECKERS

### General Earthquake-Resistance Requirements

#### General Earthquake Limitations

C NC N/A

- Seismic Design Category. Buildings in SDCs A through D<sub>2</sub> may be designed per the *IRC*; buildings in SDC E require engineered design unless the alternate determination of Seismic Design Category provisions of *IRC* Sections R301.2.2.1.1 or R301.2.2.1.2 are met. (*IRC* Section R301.2.2)
- Assembly weight. Weight of roof plus ceiling, floor, interior wall and exterior wall assemblies are limited in SDCs D<sub>1</sub> and D<sub>2</sub> and townhouses in SDC C (*IRC* Section R301.2.2.2.1).
- Number of stories. Wood light-frame buildings are limited to two stories plus cripple walls in SDC D<sub>2</sub> (*IRC* Section R301.2.2.4.1 and Table R602.10.1). Cold-formed steel framed buildings are limited to two stories above grade in SDCs D<sub>1</sub> and D<sub>2</sub> (Section R301.2.2.41). Masonry walls are limited to one story and 9 feet between lateral supports in SDCs D<sub>1</sub> and D<sub>2</sub> (*IRC* Section R606.11.3.1 and R606.11.4).
- Story height. All SDCs. Building story height is limited by the following limits on bearing wall clear height plus a maximum of 16 inches for the floor framing depth:
- |                   |  |
|-------------------|--|
| Wood light frame  | 12 ft ( <i>IRC</i> Section R301.3, Item 1 Exception)               |
| Cold-formed steel | 10 ft ( <i>IRC</i> Section R301.3, Item 2)                         |
| Masonry           | 12 ft plus 8 ft at gable ends ( <i>IRC</i> Section R301.3, Item 3) |
| ICF               | 10 ft ( <i>IRC</i> Section R301.3, Item 4, and Section 611)        |

#### Load Path

C NC N/A

- Minimum wood light frame fastening. All SDCs. (*IRC* Table R602.3)
- Anchor bolts and plate washers. *IRC* Section R403.1.6 for all SDCs. *IRC* Sections R403.1.6.1 and 602.11.1 for SDCs D<sub>1</sub> and D<sub>2</sub> and townhouses in SDC C.
- Overturning Anchorage. *IRC* Section R602.10.6 for alternate braced wall panels, all SDCs. *IRC* Section R602.10.11 Exception 2, where braced wall panels are not located at corners for SDCs D<sub>1</sub> and D<sub>2</sub>. *IRC* Section R703.7, Exceptions 3 and 4, when veneer is used for SDCs D<sub>1</sub> and D<sub>2</sub>.

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 *IRC* Section R602.10.1. In SDC D<sub>1</sub> and D<sub>2</sub>, *IRC* Section R602.10.11 last paragraph. *IRC* Section R301.2.2.2.2 for SDCs D<sub>1</sub> and D<sub>2</sub> and townhouses in SDC C.

### Irregularities

C NC N/A

- |                          |                          |                          |  |
|--------------------------|--------------------------|--------------------------|--|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Irregularity 1: Exterior braced wall panels not in one plane (stacked) from foundation to top most story in which they are required.       |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Irregularity 2: Section of floor or roof not supported by braced wall lines on all edges.  |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Irregularity 3: End of braced wall panel occurs over opening in wall below, and extends more than one foot beyond the edge of the opening. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Irregularity 4: Opening in floor or roof exceeds lesser of 12 feet or 50% of least floor or roof dimension. Figure 2-x.                    |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Irregularity 5: Portions of floor level are vertically offset (split level).   |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Irregularity 6: Braced wall lines do not occur in two perpendicular directions.  |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Irregularity 7: Stories braced by light-frame walls include concrete or masonry construction.  |

#### Above-code Recommendations:

- **Apply irregularities to all SDCs because they are also applicable for wind load.**
- **Increase first-story strength and stiffness to mitigate weak-story irregularity.**
- **Increase cripple wall strength and stiffness to mitigate weak-story irregularity.**

## Foundations and Foundation Walls

### General

C NC N/A

- |                          |                          |                          |   |
|--------------------------|--------------------------|--------------------------|---|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Continuous perimeter foundations. All exterior walls are to be supported on continuous perimeter foundations. All SDCs. ( <i>IRC</i> Section R403.1)  |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Continuous interior foundations. At interior braced wall lines in buildings with plan dimensions greater than 50 ft. SDCs D <sub>1</sub> and D <sub>2</sub> . ( <i>IRC</i> Section R403.1.2). |

### Special Soils Conditions

C NC N/A

- Low bearing capacity. Soils investigation required when building official determines that soil bearing capacities of less than 1500 psf might be present at site. All SDCs. (*IRC* Table R401.4.1, footnote b)
- Soil testing when expansive, compressible, or shifting soils are encountered or are likely. (*IRC* Section R401.4)
- Frost protection. Footings are to be below the frost line or adequate frost protection should be provided. (*IRC* Section R403.1.4.1)

### Concrete Foundations

C NC N/A

- Minimum concrete strength. 2500 psi for all SDCs. 3000 or 3500 psi in moderate or severe weathering probability areas. (*IRC* Section R402.2 and Table R402.2)
- Horizontal reinforcing. One No.4 in footing and second No. 4 in stem wall. No. 4 top and bottom in thickened slab footing with alternative of one No. 5 or two No.4 in middle third of footing height for thickened slab footings cast monolithically with slab. SDCs D<sub>1</sub> and D<sub>2</sub>. (*IRC* Sections R403.1.3 and R403.1.3.2)
- Vertical reinforcing. No. 4 at 48 inches maximum spacing required where a pour joint occurs between concrete footing and concrete stem wall. SDCs D<sub>1</sub> and D<sub>2</sub>. (*IRC* Section R403.1.3)

### Masonry Foundations

C NC N/A

- Masonry foundation type. Solid clay masonry and fully grouted concrete masonry permitted in all SDCs (*IRC* Section R403.1). Rubble stone masonry foundation walls limited to SDCs A through C (*IRC* Section R404.1.1).
- Horizontal reinforcing. One No. 4 in footing and second No. 4 in stem wall. SDCs D<sub>1</sub> and D<sub>2</sub>. (*IRC* Section R403.1.3 and R403.1.3.1)
- Vertical reinforcing. Minimum No.4 at 4 feet on center extending into footing with standard hook. SDCs D<sub>1</sub> and D<sub>2</sub>. (*IRC* Section R403.1.3)

## Foundation Walls

C NC N/A

- Wall thickness. Six inches minimum up to 12 inches required based on soil type at site. SDCs A through D<sub>2</sub>. (*IRC Table R401.1.1(1)*).
- Horizontal reinforcing. Dependent upon all thickness and material. Minimum No. 4 in upper 12 inches of wall. SDCs D<sub>1</sub> and D<sub>2</sub>. (*IRC Sections R404.1.4 and R606.11*).
- Vertical reinforcing. Varies depending on wall height and soil type at site. ASTM Grade 60 minimum. All SDCs. (*IRC Tables R404.1.1(2)*).

### 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 No. 4 reinforcing bar in concrete footings. Provide a second No. 4 in stem wall if present. This will provide tension and bending capacity to help mitigate foundation damage due to earthquake, wind, soil movement, and frost heave.**

**In SDCs C, D<sub>1</sub> and D<sub>2</sub>, provide not less than No. 4 vertical bars at 4 feet as dowels between a concrete footing and separately cast slab-on-grade.**

**In concrete foundations, lap reinforcing bars not less than 24 inches. Bend radius (outer) for No. 4 bar is 2 inches and 2-1/2 inches for No. 5. Hook at corners and intersections of 8 inches for No.4 bars and 10 inches for No. 5 bars.**

**Regardless of SDC, provide not less than one continuous No. 4 reinforcing bar in masonry foundation stem walls.**

**In masonry foundation walls and stem walls, lap reinforcing bars not less than 24 inches. Bend radius (outer) for No. 4 bar is 2 inches 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.**

## Floor Construction

C NC N/A

- Blocking or lateral restraint. Required at intermediate floor framing member supports. SDCs D<sub>1</sub> and D<sub>2</sub>. (*IRC Section R502.7, Exception*).

### Light-Frame Wall Construction

**C NC N/A**

- Braced wall length required for each 25 ft of wall length. (*IRC* Section R602.10.6)
- Sheathing attachment spacing. (Various *IRC* sections)

### Cold-formed Steel Construction

**C NC N/A**

- Cold-formed steel framing. Buildings in SDCs D<sub>1</sub> and D<sub>2</sub> need to comply with the *AISI Standard for Cold-Formed Steel Framing – Prescriptive Method for One- and Two-Family Dwellings* in addition to the requirements of the *IRC* Section R301.2.2.4.5.

### Masonry Wall Buildings

**C NC N/A**

- Limited to one story for SDCs D<sub>1</sub> and D<sub>2</sub>. (*IRC* Section R606)
- In SDCs D<sub>1</sub> and D<sub>2</sub>, 9 feet between lateral supports. (*IRC* Section R606.8)
- Light-frame restricted from supporting lateral loads from masonry. (*IRC* Section R301.2.2.2.2)
- Reinforcement detailing (*IRC* Section R606.11).

### Concrete and Insulating Concrete Form Wall Buildings

**C NC N/A**

- Limited to two stories above grade. (*IRC* Section R611)
- Minimum wall thickness of 5.5 inches for IFC and 6 inches for solid concrete. (*IRC* Section R611.7.4)
- Maximum plan dimension of 60 feet and aspect ratio of 2:1. (*IRC* Section R611.2)
- Reinforcement detailing. (*IRC* Sections R611.3 - R611.5 and R611.7.1.2 and R611.7.1.3)

## Stone and Masonry Veneer

**C NC N/A**

- Veneer. In SDCs D<sub>1</sub> and D<sub>2</sub>, veneer is not permitted on buildings with cripple walls. (*IRC* Section R703.7, Exceptions 3 and 4)

## Fireplaces and Chimneys

**C NC N/A**

- Vertical reinforcement requirements (four No. 4 Bars). (*IRC* Section R1003.3)
- Type N mortar prohibited in SDCs D<sub>1</sub> and D<sub>2</sub>. (*IRC* Section R609)
- Anchorage requirements for SDCs D<sub>1</sub> and D<sub>2</sub>. (*IRC* Section R1003.4)

## Appendix D

### **SIGNIFICANT CHANGES FOR THE 2006 *INTERNATIONAL RESIDENTIAL CODE***

During the 2006 cycle of technical updates for the *International Residential Code (IRC)*, a number of important technical changes were made that will have an impact on many houses around the country. This appendix highlights the most significant of these changes so that the designer can continue to use this document when the 2006 *IRC* is adopted by his or her jurisdiction.

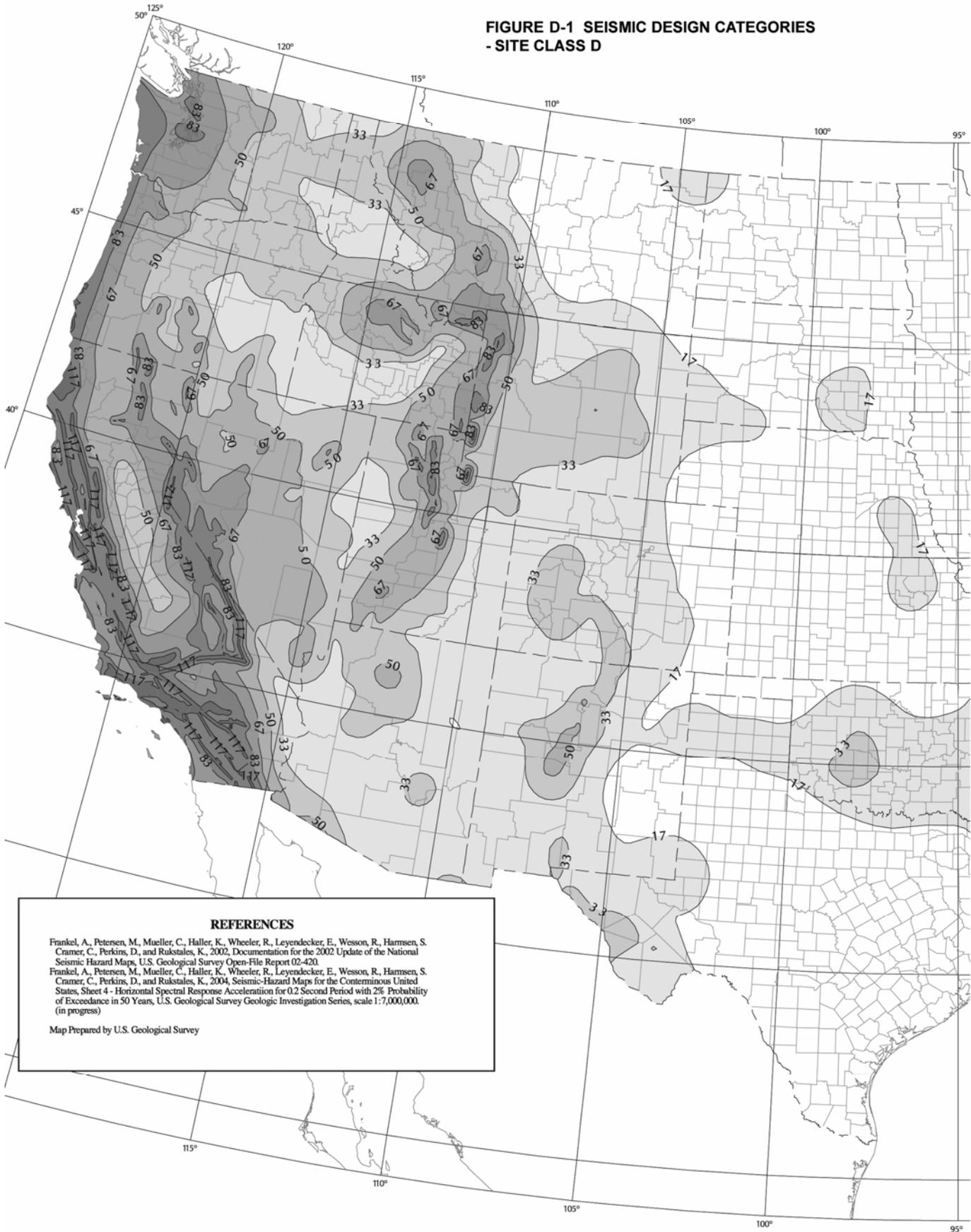
#### **D1 REVISED SEISMIC DESIGN MAPS**

In response to concerns over the perceived increases in earthquake design forces that were implemented with the adoption of the 2000 editions of the *International Building Code (IBC)* and *IRC*, the U.S. Geological Survey (USGS) conducted a detailed evaluation of earthquake risk on a county-by-county basis for regions with a high probability of earthquake occurrence. The project incorporated significant new information about local geological and geotechnical features and local experts for the regions being investigated were consulted. The result of the project is revised design maps that are incorporated into the 2006 editions of the *IRC* and *IBC*. In general, the new maps reduce the amount of geographic area affected by the high seismic risk, but the remaining area is also affected to some extent. This is primarily evident in the Charleston, South Carolina, region where the Seismic Design Category was raised in the counties closest to Charleston, but the rest of the state experiences a reduction in seismic risk level. The seismic design map that was adopted for the 2006 *IRC* is shown in Figure D-1 on the following pages.

#### **D2 ADDITION OF SEISMIC DESIGN CATEGORY D<sub>0</sub>**

In addition to provide some relief for the construction of houses using heavier finish materials such as masonry veneers and stucco, Seismic Design Category D<sub>1</sub> was divided into two SDCs – D<sub>0</sub> and D<sub>1</sub>. Since design values must be set to the highest value in the range, dividing the original D<sub>1</sub> into two lowered the earthquake design load for the lower design category. Only the brick masonry veneer industry has started to take advantage of this change to date. However, it is expected that other materials also will propose changes in the future to take advantage of the lower forces associated with Seismic Design Category D<sub>0</sub>. The geographic area associated with the change can be seen in Figure D-1.

**FIGURE D-1 SEISMIC DESIGN CATEGORIES  
- SITE CLASS D**

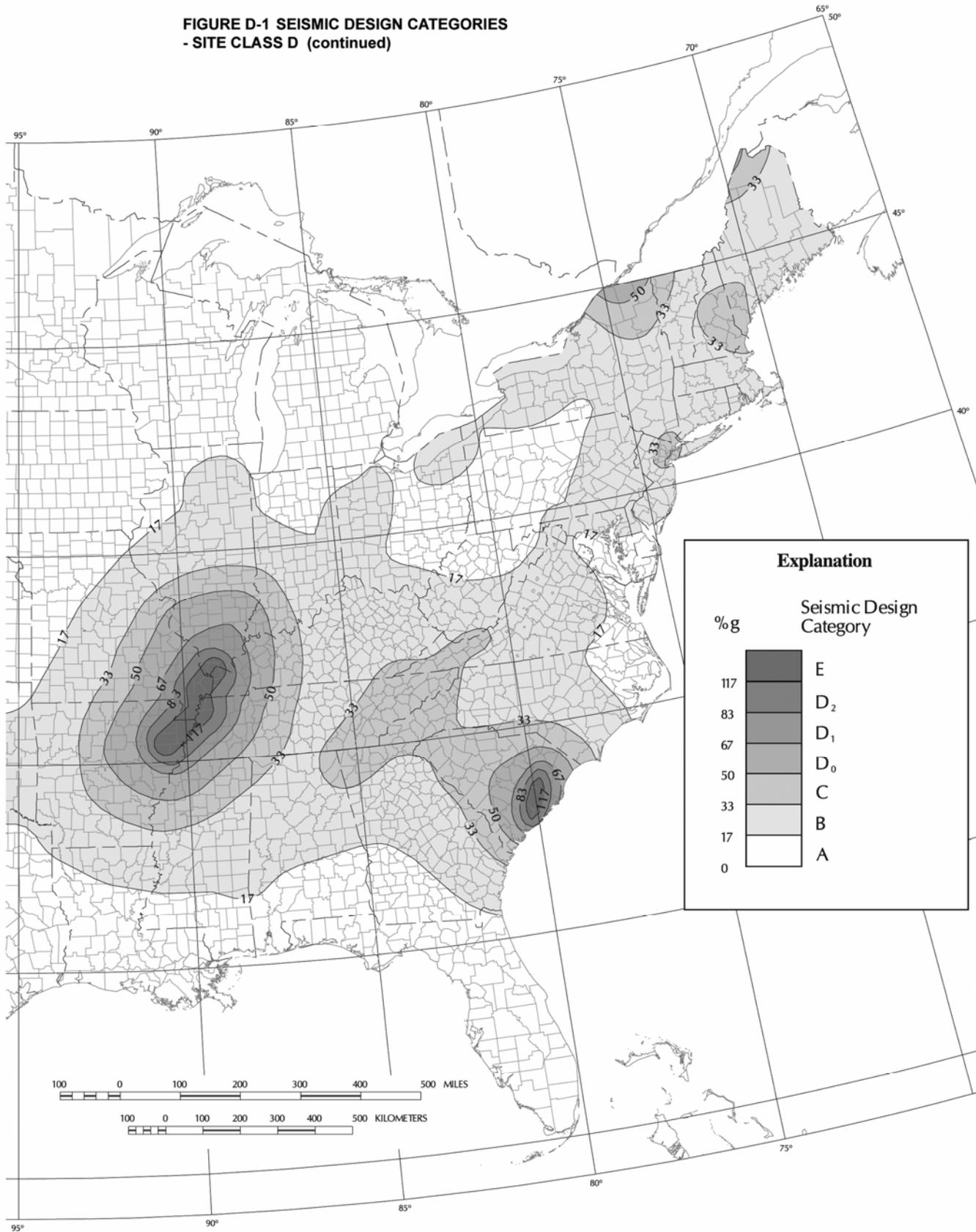


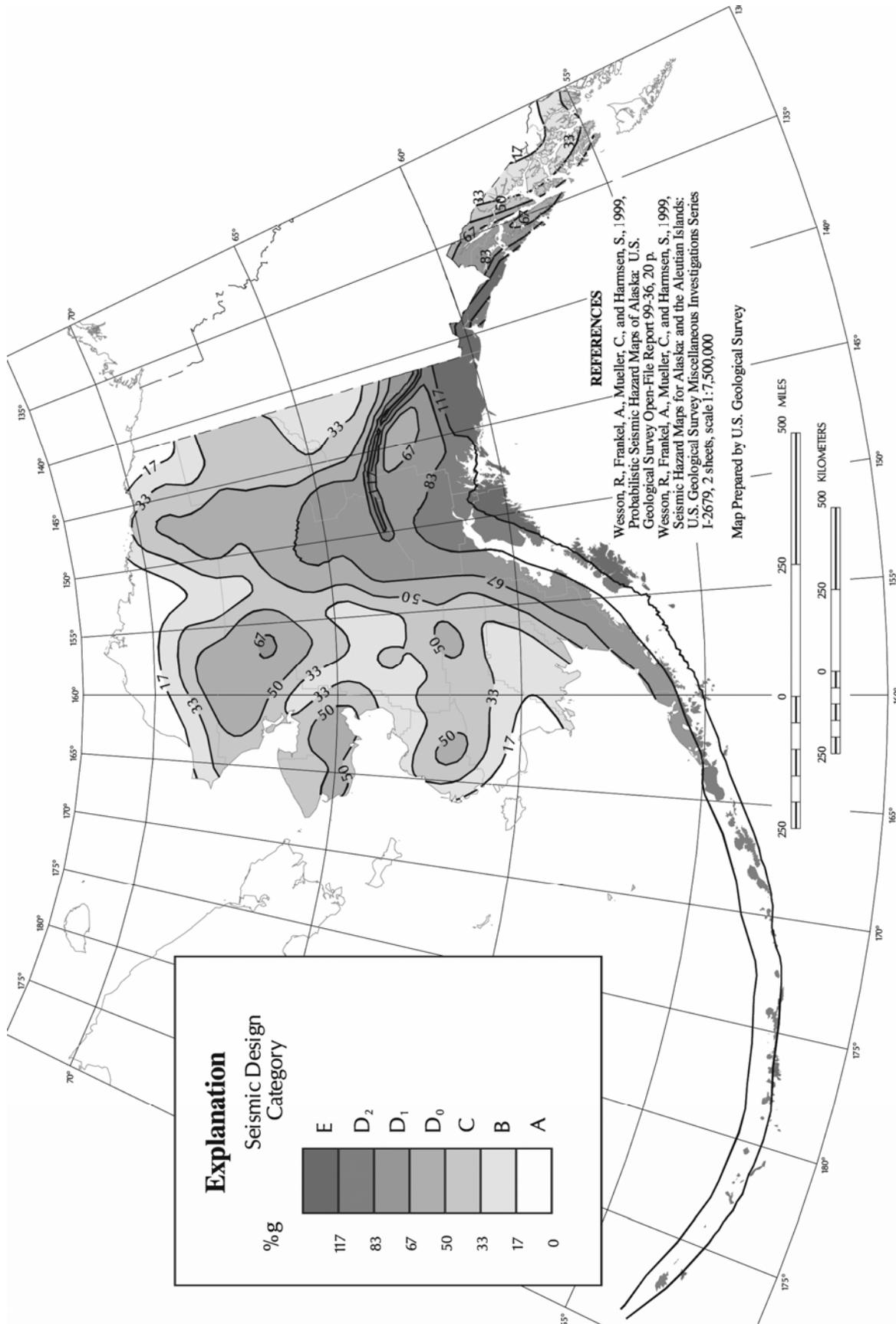
**REFERENCES**

Frankel, A., Petersen, M., Mueller, C., Haller, K., Wheeler, R., Leyendecker, E., Wesson, R., Harnsen, S., Cramer, C., Perkins, D., and Rukstales, K., 2002. Documentation for the 2002 Update of the National Seismic Hazard Maps, U.S. Geological Survey Open-File Report 02-420.  
 Frankel, A., Petersen, M., Mueller, C., Haller, K., Wheeler, R., Leyendecker, E., Wesson, R., Harnsen, S., Cramer, C., Perkins, D., and Rukstales, K., 2004. Seismic-Hazard Maps for the Conterminous United States, Sheet 4 - Horizontal Spectral Response Acceleration for 0.2 Second Period with 2% Probability of Exceedance in 50 Years, U.S. Geological Survey Geologic Investigation Series, scale 1:7,000,000. (in progress)

Map Prepared by U.S. Geological Survey

**FIGURE D-1 SEISMIC DESIGN CATEGORIES**  
**- SITE CLASS D (continued)**

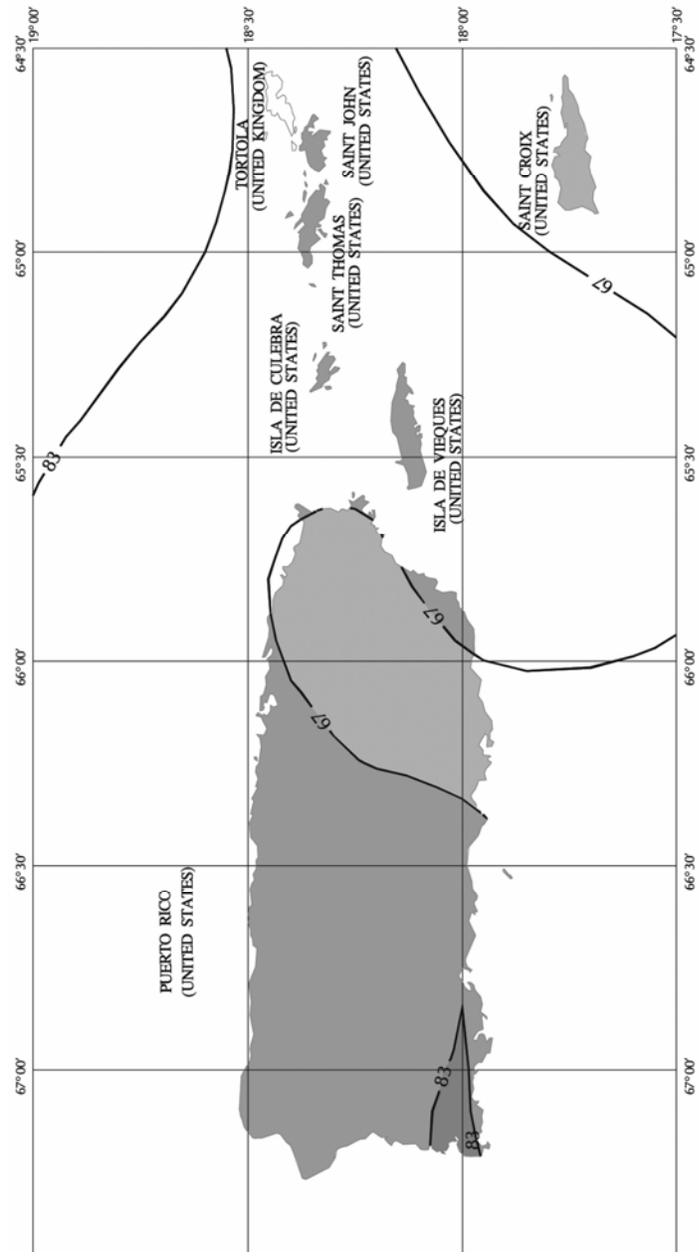




**FIGURE D-1 SEISMIC DESIGN CATEGORIES**  
**- SITE CLASS D (continued)**



**FIGURE D-1 SEISMIC DESIGN CATEGORIES**  
-SITF CLASS D (continued)



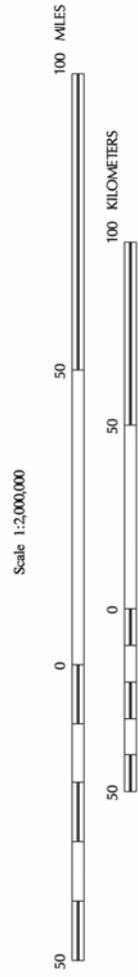
Explanation	
% g	Seismic Design Category
117	E
83	D <sub>2</sub>
67	D <sub>1</sub>
50	D <sub>0</sub>
33	C
17	B
0	A

**REFERENCES**

Mueller, C., Frankel, A., Petersen, M., and Leyendecker, E., 2003, Documentation for 2003 USGS Seismic Hazard Maps for Puerto Rico and the U.S. Virgin Islands, U.S. Geological Survey Open-File Report 03-379.

Mueller, C., Frankel, A., Petersen, M., and Leyendecker, E., 2004, Seismic-Hazard Maps for Puerto Rico and the U.S. Virgin Islands, Sheet 2 - 2% Probability of Exceedance in 50 Years for Peak Horizontal Acceleration and Horizontal Spectral Response Acceleration for 0.2, 0.3, and 1.0 Second Periods U.S. Geological Survey Geologic Investigation Series (in progress).

Map Prepared by U.S. Geological Survey



**FIGURE D-1 SEISMIC DESIGN CATEGORIES**  
**- SITE CLASS D (continued)**

### **D3 CHANGE IN APPLICABILITY OF IRREGULAR BUILDING REQUIREMENTS**

During the update cycle resulting in the 2006 *IRC*, it was noticed that the wording requiring that the building conform to the requirements of *IRC* Section R301.2.2.2.2 only applied to wood and ICF concrete construction. Cold-formed steel construction had to conform to these irregularity requirements even through the referenced design and construction document (COFS/PM) had less stringent requirements and application to masonry wall buildings was not specified. Thus, a change was made to require all buildings to conform to the irregularity provisions of the *IRC*, which limit the concentrations of loads and deformations that irregularities cause.

### **D4 CLARIFICATION AND ADDITION OF REQUIREMENTS FOR MASONRY VENEER**

A significant change was made to the requirements for the use of stone and masonry veneer in areas of high earthquake risk. The changes clarify veneer weight limits and stories where veneer is permitted. They also clarify and illustrate the required hold-down anchorage of walls and the requirements for ties and other reinforcement and attachment of the veneer to the walls. The change is too extensive to document here; rather, the reader is referred to the 2006 *IRC* for details.



## **Appendix E**

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## **Appendix F**

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## **THE BUILDING SEISMIC SAFETY COUNCIL**

The purpose of the Building Seismic Safety Council is to enhance the public's safety by providing a national forum to foster improved seismic safety provisions for use by the building community. For the purposes of the Council, the building community is taken to include all those involved in the planning, design, construction, regulation, and utilization of buildings.

To achieve its purposes, the Council shall conduct activities and provide the leadership needed to:

- Promote development of seismic safety provisions suitable for use throughout the United States;
- Recommend, encourage, and promote adoption of appropriate seismic safety provisions in voluntary standards and model codes;
- Assess implementation progress by federal, state, and local regulatory and construction agencies;
- Identify opportunities for the improvement of seismic regulations and practices and encourage public and private organizations to effect such improvements;
- Promote the development of training and educational courses and materials for use by design professionals, builders, building regulatory officials, elected officials, industry representatives, other members of the building community and the public.
- Provide advice to governmental bodies on their programs of research, development, and implementation; and
- Periodically review and evaluate research findings, practice, and experience and make recommendations for incorporation into seismic design practices.

The scope of the Council's activities encompasses seismic safety of structures with explicit consideration and assessment of the social, technical, administrative, political, legal, and economic implications of its deliberations and recommendations.

Achievement of the Council's purpose is important to all in the public and private sectors. Council activities will provide an opportunity for participation by those at interest, including local, State, and Federal Government, voluntary organizations, business, industry, the design professions, the construction industry, the research community and the public. Regional and local differences in the nature and magnitude of potentially hazardous earthquake events require a flexible approach adaptable to the relative risk, resources and capabilities of each community. The Council recognizes that appropriate earthquake hazard reduction measures and initiatives should be adopted by existing organizations and institutions and incorporated into their legislation, regulations, practices, rules, codes, relief procedures and loan requirements, whenever possible, so that these measures and initiatives become part of established activities rather than being superposed as separate and additional.

The Council is established as a voluntary advisory, facilitative council of the National Institute of Building Sciences, a nonprofit corporation incorporated in the District of Columbia, under the authority given the Institute by the Housing and Community Development Act of 1974, (Public Law 93-383), Title VIII, in furtherance of the objectives of the Earthquake Hazards Reduction Act of 1977 (Public Law 95-124) and in support of the President's National Earthquake Hazards Reduction Program, June 22, 1978.

