

Use of Performance-Based Engineering Criteria In Motivating Residential Seismic Retrofit

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Past Practice

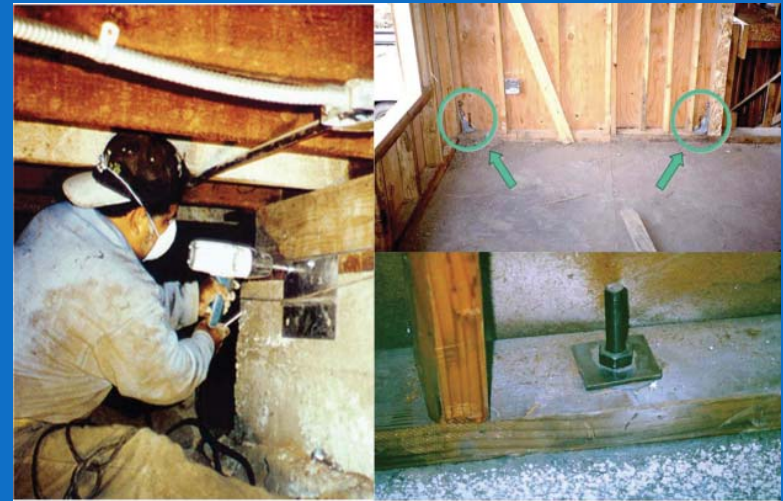
- History of dwelling damage
- Seismic retrofit of dwellings is usually voluntary
- Retrofit is encouraged, but not widely implemented
- Focus is on retrofit of building portions that cause extensive damage and possible risk to occupants
- Standardized methods of evaluating vulnerability have not existed
- Retrofit objective is related to damage reduction, without discussion of resulting building performance



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New Document & Assessment Method

- Funded by FEMA
- Prepared by ATC
- Update of precursor documents ATC-50 and ATC-50-1, developed following Northridge Earthquake
- Goal: To develop a tool to encourage the seismic retrofitting of residential structures, thereby reducing future earthquake losses



Simplified Seismic Assessment of Detached, Single-Family, Wood-Frame Dwellings

FEMA P-50 / May 2012



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Assessment Form

FEMA P-50		Simplified Seismic Assessment Form		Grade <input type="text"/>		
For Detached, Single-Family, Wood-Frame Dwellings						
(Please print all information)						
Street Address		Community/Area/City		ZIP Code	Date	
Owner			Inspector		Inspection Form # (optional)	
For each question, <u>circle only one answer</u> . Circle the one with higher penalty if more than one answer applies. <u>Exception: question B-1</u>						
A. Foundation (If the dwelling has a crawl space, the inspector should view all the areas that are accessible.)						
			Penalty			
*A-1 The exterior footing is:				*A-5 At the dwelling perimeter walls, where the foundation system supports a wood framed floor:		
a. continuous concrete or reinforced masonry			[0]	a. the foundation sill plate (mudsill) is bolted to the foundation with average anchor bolt spacing of 72 in. or less		
b. other footing conditions			[4.2]	b. the foundation sill plate is fastened to the foundation with retrofit anchors equivalent to 72 in. or less anchor bolt spacing		
A-2 The lowest floor of the dwelling is:				c. the anchor bolts have average spacing that is > 72 in. but <= 108 in.		
a. slab-on-grade			[0]	d. the anchor bolts have > 108 in. average spacing		
b. wood framed over crawl space or basement			[2.9]	e. the foundation sill plates have extensive decay, splitting, or inadequate edge distance at one-third or more of the anchor bolt locations such that significant slip of the sill plate could occur		
c. combination of slab-on-grade and wood framed floor over crawl space or basement			[2.9]	f. the anchor bolts have significant corrosion at one third or more of the anchor bolt locations such that significant slip of the sill plate could occur		
*A-3 At the dwelling crawlspace or basement interior, the lowest floor framing is supported on:				g. there are no foundation anchor bolts		
a. continuous stem walls or a combination of continuous stem walls and beams on posts bearing on concrete footings/piers			[0]	h. there are no foundation sill plates to connect to the foundation		
b. beams on posts bearing on piers/pad footings			[0.8]	i. not applicable		
c. beams on posts supported directly on soil			[2.2]			
d. not applicable: slab-on-grade			[0]			
A-4 For a foundation on a slope of 3 horizontal to 1 vertical or steeper, the top of the footing or foundation stem wall on which wall studs or posts are supported is:				Total <input type="text"/>		
a. sloped parallel to the ground slope			[3.7]			
b. stepped			[1.8]			
c. at a constant elevation with no steps			[0.6]			
d. not applicable			[0]			
B. Superstructure Framing and Configuration (Every accessible area such as the attic and under-floor area that reveals structural elements must be inspected.)						
			Penalty			
			Penalty			

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Assessment Form

Allow you to:

- Assign a Seismic Performance Grade



D+

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Assessment Form

Allow you to:

- Assign a Seismic Performance Grade
- Identify seismic retrofit opportunities & priorities

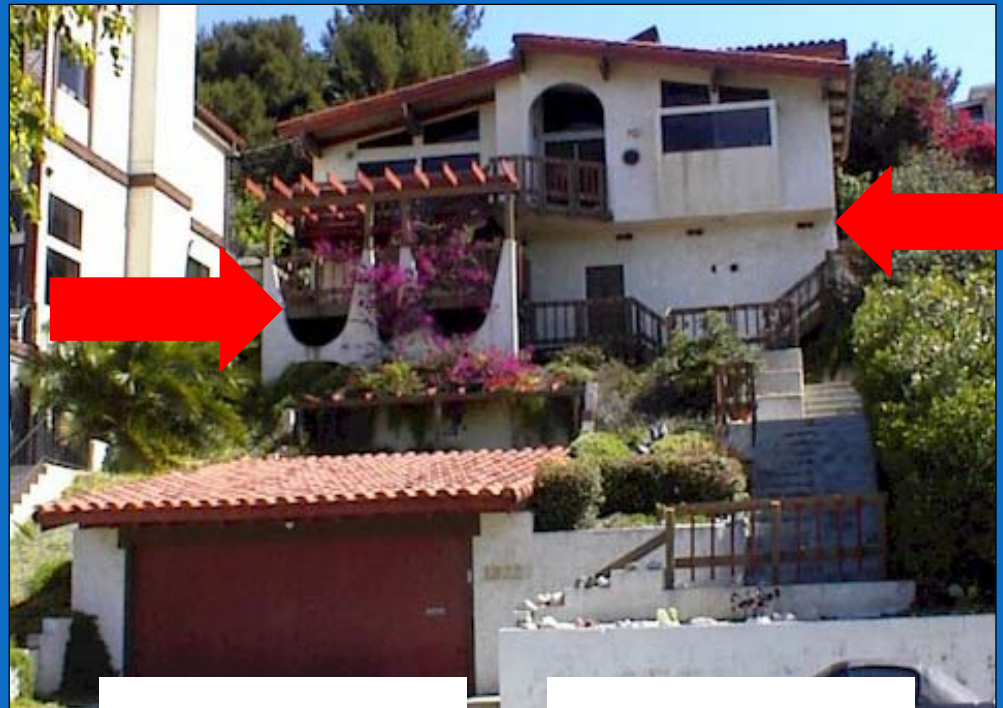


D+

Assessment Form

Allow you to:

- Assign a Seismic Performance Grade
- Identify seismic retrofit opportunities & priorities
- Identify an improved Seismic Performance Grade if seismic retrofit occurs



~~D+~~

B+

Seismic Performance Grade

Table 5. Seismic Performance Grade Based on Structural Score and Seismic Hazard Score

Seismic Hazard Score		0 - 1	2 - 3	4 - 5	6 - 7	8 - 9	10 - 12
Structural Score	1.0 - 45.9	C	C-	D+	D	D-	D-
	46.0 - 64.9	B-	C+	C	D+	D	D-
	65.0 - 74.9	B+	B+	B	C	C-	D+
	75.0 - 84.9	A-	A-	A-	B	B-	C
	85.0 - 100	A	A	A	A-	B+	B-

Seismic Performance Grade A through D

- Generally anticipated seismic performance
- Given structural characteristics & geographic location
- Relative to overall group of detached wood-framed single-family dwellings

Structural Score

Structural Evaluation Areas:

- A. Foundation
- B. Superstructure Framing and Configuration
- C. General Condition Assessment
- D. Nonstructural Elements, Age and Size
- E. Local Site Conditions

**Structural
Score: 100**

Structural Score

A. Foundation: (If the dwelling has a crawl space, the inspector shall inspect the foundation.)

*A-1 The exterior footing is:

- a. continuous concrete or reinforced masonry [0]
- b. other footing conditions [4.2]



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Structural Score

**Structural
Score: 88.9**

A. Foundation: (If the dwelling has a crawl space, the inspector should view all the areas that are accessible.)

*A-1 The exterior footing is:			
a. continuous concrete or reinforced masonry	[0]		
b. other footing conditions	[4.2]		
A-2 The lowest floor of the dwelling is:			
a. slab-on-grade	[0]		
b. wood framed over crawl space or basement	[2.9]		
c. combination of slab-on-grade and wood framed floor over crawl space or basement	[2.9]		
*A-3 At the dwelling crawlspace or basement interior, the lowest floor framing is supported on:			
a. continuous stem walls or a combination of continuous stem walls and beams on posts bearing on concrete footings/piers	[0]		
b. beams on posts bearing on piers/pad footings	[0.8]		
c. beams on posts supported directly on soil	[2.2]		
d. not applicable: slab-on-grade	[0]		
A-4 For a foundation on a slope of 3 horizontal to 1 vertical or steeper, the top of the footing or foundation stem wall on which wall studs or posts are supported is:			
a. sloped parallel to the ground slope	[3.7]		
b. stepped	[1.8]		
c. at a constant elevation with no steps	[0.6]		
d. not applicable	[0]		
*A-5 At the dwelling perimeter walls, where the foundation system supports a wood framed floor:			
a. the foundation sill plate (mudsill) is bolted to the foundation with average anchor bolt spacing of 72 in. or less	[0]		
b. the foundation sill plate is fastened to the foundation with retrofit anchors equivalent to 72 in. or less anchor bolt spacing	[0]		
c. the anchor bolts have average spacing that is > 72 in. but <= 108 in.	[1.7]		
d. the anchor bolts have > 108 in. average spacing	[4.6]		
e. the foundation sill plates have extensive decay, splitting, or inadequate edge distance at one third or more of the anchor bolt locations such that significant slip of the sill plate could occur	[10.0]		
f. the anchor bolts have significant corrosion at one third or more of the anchor bolts locations such that significant slip of the sill plate could occur	[10.0]		
g. there are no foundation anchor bolts	[15.0]		
h. there are no foundation sill plates to connect to the foundation	[15.0]		
i. not applicable	[0]		
		Total	11.1

Structural Score

*B-3 If the roofing is heavy (i.e., clay or concrete tile) the dwelling is:

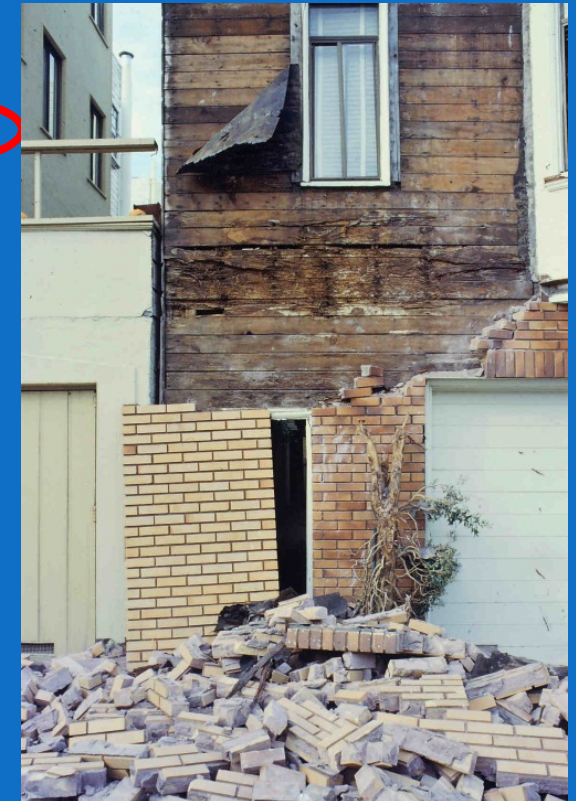
- | | |
|--------------------------------------|-------|
| a. single story | [1.6] |
| b. multi-story | [3.5] |
| c. not applicable: roofing is light. | [0] |



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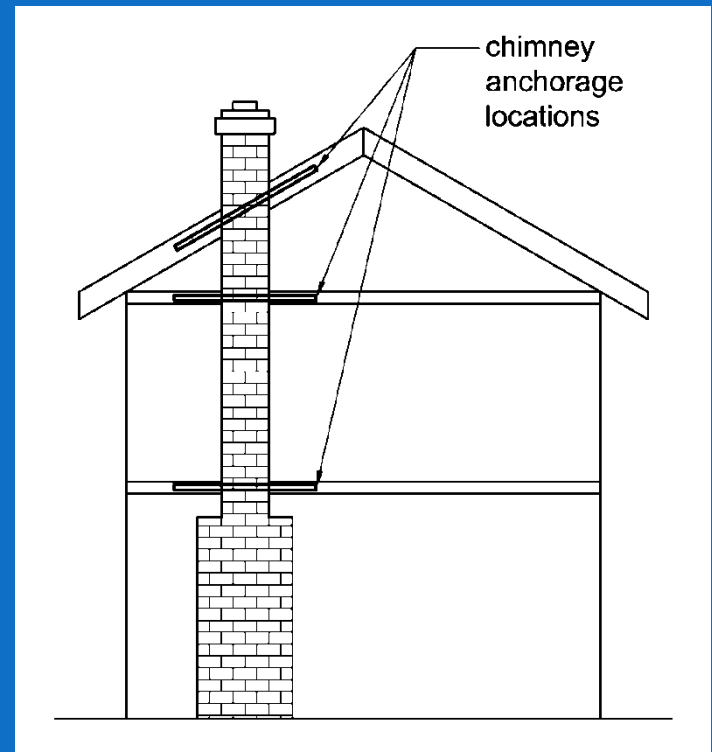
Structural Score

- *B-5 The exterior wall covering is primarily:
- a. siding known to be over plywood or OSB sheathing [0]
 - b. siding not known to be over plywood or OSB sheathing [2.5]
 - c. plywood (T1-11) or diagonal wood siding [0]
 - d. stucco [1.0]
 - e. masonry veneer not more than 10 feet above the supporting foundation [2.5]
 - f. masonry veneer more than 10 feet above the supporting foundation [3.5]



Structural Score

D. Nonstructural Elements, Age, and Size		<u>Penalty</u>
*D-1 The chimney inspection revealed:		
a. properly connected anchor straps tying the masonry/concrete chimney(s) at side of house to the floor, ceiling and roof framing	yes	[1.0]
	no	[2.0]
b. chimney occurs at dwelling interior		[1.0]
c. dwelling has no masonry/concrete chimney		[0]
*D-2 The gas water heater has effective anchor straps and water and gas connections:		
	yes	[0]
	no	[1.0]
The electric water heater has approved anchor straps:		
	yes	[0]
	no	[0.7]
*D-3 An earthquake-activated gas shut-off valve is installed:		
	yes	[0]
	no	[1.0]
	not applicable	[0]



*Assessment item that may be improved by seismic retrofit; see page

Structural Score

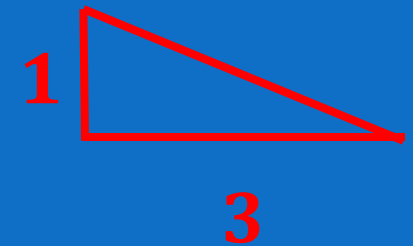
D. Nonstructural Elements, Age, and Size		<u>Penalty</u>
*D-1 The chimney inspection revealed:		
a. properly connected anchor straps tying the masonry/concrete chimney(s) at side of house to the floor, ceiling and roof framing	yes	[1.0]
	no	[2.0]
b. chimney occurs at dwelling interior		[1.0]
c. dwelling has no masonry/concrete chimney		[0]
*D-2 The gas water heater has effective anchor straps and water and gas connections:		
	yes	[0]
	no	[1.0]
The electric water heater has approved anchor straps:		
	yes	[0]
	no	[0.7]
*D-3 An earthquake-activated gas shut-off valve is installed:		
	yes	[0]
	no	[1.0]
	not applicable	[0]
*Assessment item that may be improved by seismic retrofit; see page		



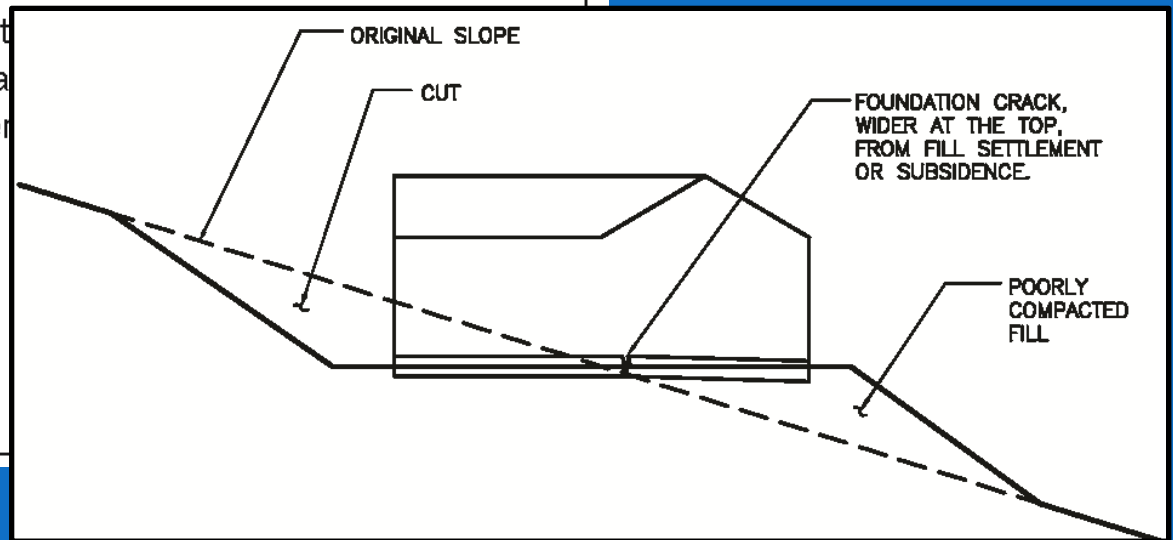
Structural Score

E. Local Site Conditions

	<u>Penalty</u>
E-1 The dwelling is located primarily on:	
a. a flat lot or slope ($\leq 3:1$)	[0]
b. steep slope ($> 3:1$)	[3.0]
E-2 The dwelling is located on a cut-and-fill pad, which was developed:	
a. without a geotechnical investigation	[2.7]
b. with a geotechnical investigation	[1.3]
c. dwelling is <i>not</i> on cut-and-fill pad	[0]



- *E-3 The exterior concrete footings:
- a. no visible cracks or a crack width less than 1/8 inch
 - b. minor cracks in several locations
 - c. extensive cracking
 - d. not applicable



Seismic Performance Grade

G. Determination of Seismic Performance Grade

1. Structural Score	<u>Penalty Sum</u>	4. Anticipated Seismic Performance ¹
a. Foundation (Section A)	[11.1]	Following anticipated seismic events: ²
b. Superstructure Framing and Configuration (Section B)	[27.3]	Grade A, A-: Excellent Performer (Potential minor structural and finish damage, earthquake damage ratio ³ of 0%-10%, continued occupancy is likely)
c. General Condition Assessment	[1.8]	Grade B, B+, B-: Good Performer (Potential moderate structural and finish damage, continued occupancy likely following minor structural repairs, earthquake damage ratio ³ of 0%-50%, seismic retrofit measures are encouraged)
d. Nonstructural Elements, Age, and Size (Section D)	[6.0]	Grade C, C+, C-: Fair Performer (Potential moderate to major structural and finish damage, structural repairs may be required prior to continued occupancy, earthquake damage ratio ³ of 10%-60%, seismic retrofit measures are strongly encouraged)
e. Local Site Conditions (Section E)	[3.3]	Grade D, D+, D-: Poor Performer (Potential severe structure and finish damage requiring significant repairs prior to re-occupancy, earthquake damage ratio ³ of 20% – 100%, significant seismic retrofit measures are strongly encouraged)
Total Penalty Points (a to e):	50.5	
Structural Score = (100 – Total Penalty points from line above):	49.5	
2. Seismic Hazard Score (from Section F):	<input type="text"/>	
3. Seismic Performance Grade (from Table 5) Note: insert this grade, including + or -, if applicable in box on page 1	<input type="text"/>	

Regional Seismic Hazard Score

F. Regional Seismic Hazard Score

F-1 Enter points for shaking hazard potential for location of dwelling (from Table 1). [_____]

F-2 Are ground failure hazards to be looked up using Tables 2, 3, and 4? yes, go to F-3.
no, proceed to F-6 and enter 4.0 points for ground failure hazards

F-3 Is this dwelling located in a liquefaction zone (from Table 2) or landslide zone (from Table 3)? yes, go to F-4.
no, go to F-5.

F-4 Proceed to F-6 and enter ground failure hazard points in accordance with the following table:

Ground Shaking Points	Ground Failure Points
0	2
2, 4	3
6, 8	4

F-5 Is the dwelling located in a fault rupture zone (from Table 4)? yes [2]
no [0]

F-6 Total ground failure points from F-2, F-4, or F-5 (no summation). [_____]

Total Seismic Hazard Score (Sum of F-1 and F-6)

Regional Seismic Hazard Score

Table 1. Assignment of Ground Shaking Hazard Score

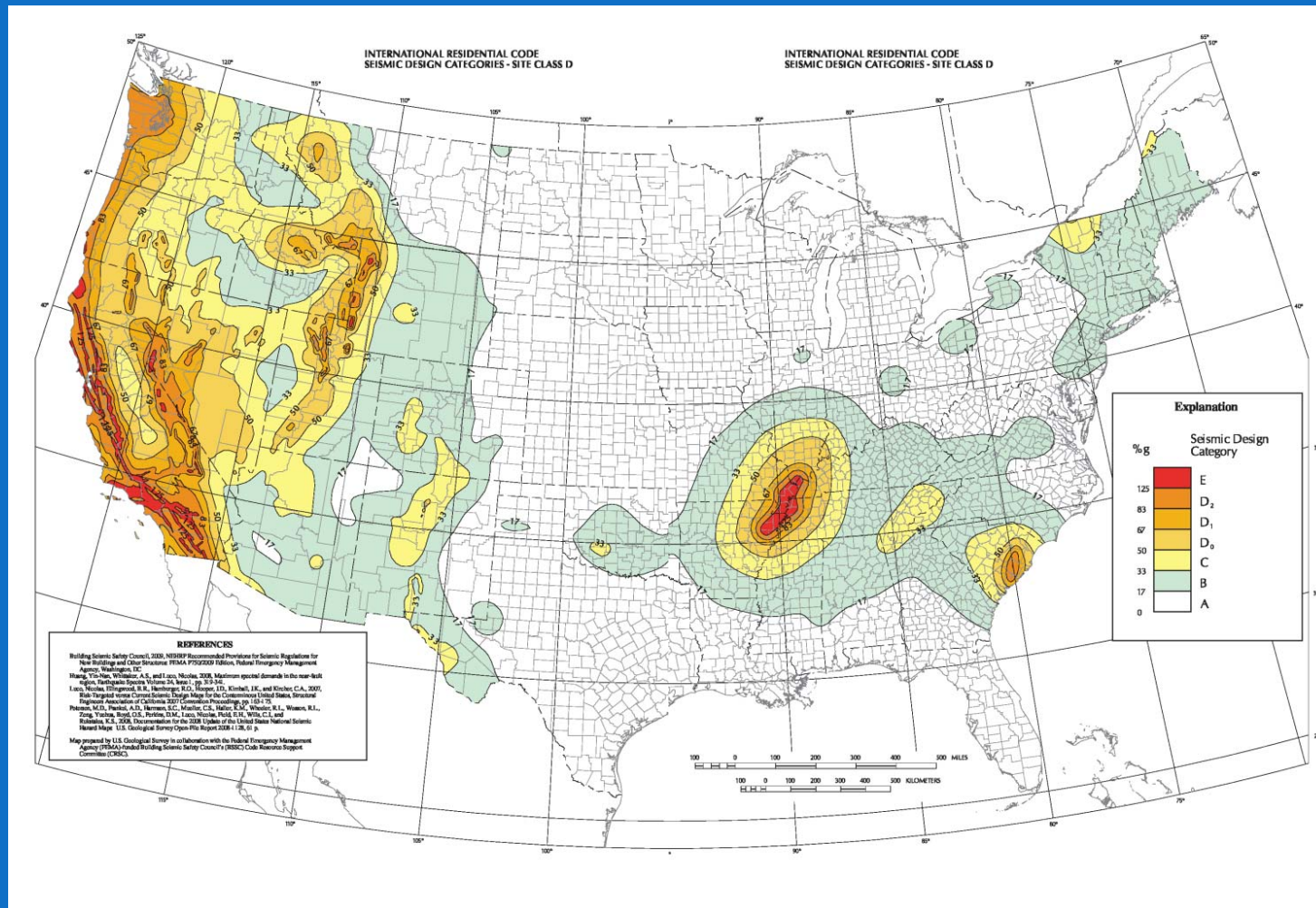
1. Use the USGS Seismic Design Maps Web Application (<http://earthquake.usgs.gov/designmaps/usapp>)¹ to look up ground shaking parameter S_{DS} :
 - a. Press the 'Launch Application' button.
 - b. In the web application, select '2012 IBC' for the Building Code Reference Document.
 - c. Select 'Site Class D – "Stiff Soil" (Default)' for the Site Soil Classification.
 - d. Enter the site address or latitude and longitude.
 - e. Press the 'Compute Values' button.
 - f. Read parameter S_{DS} from the summary report. Enter here: _____ g
 - g. Multiply value from 1f by 100: _____ %g
2. Using the value from 1g, assign ground shaking points according to the following table (these points are assigned in Item F-1):

Value of S_{DS} (% g)	Ground Shaking Hazard Points
33 - 66.99	0
67 - 82.99	2
83 - 124.99	4
125 - 187.99	6
188 - 250	8

¹Note: If you are using the USGS application for the first time, or have recently cleared your web browser cookies, you may have to register for immediate use. Also, if you are using an anti-virus software program, you may have to enable some links to this site, e.g., if you receive a message that says "only secure content is displayed," you must click on "show all content."

<http://earthquake.usgs.gov/designmaps/usapp>

Regional Seismic Hazard Score



<http://earthquake.usgs.gov/designmaps/usapp>

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December 2012

Regional Seismic Hazard Score

Table 2. Assignment of Site as Being Within a Liquefaction Zone

1. If site is in California, locate site on the California Emergency Management Agency (Cal EMA) MyPlan web site (myplan.calema.ca.gov).
 - a. Enter address in 'Find Location' window.
 - b. Select 'liquefaction' in menu bar to right of map.
 - c. Zoom as needed to see map details.
 - d. If site is located within green zone on map, answer to Question F-3 is 'yes'.
 - e. If site located in non-liquefaction and non-seismic landslide zone on map (generally pale yellow), answer to Question F-3 is 'no'.
 - f. Site not mapped if background is stippled. Go to Step (2).
2. If site is not on Cal EMA web site, determine site liquefaction potential/susceptibility using available web resources. See www.ATCCouncil.org/pdfs/FEMAP-50LiquefactionInfo.pdf for a list of such resources. Map types shown in these web resources are:
 - a. Liquefaction susceptibility maps. Answer to F-3 is 'yes' if site is in a zone of moderate-to-high liquefaction susceptibility. Answer is 'no' if in a low susceptibility or non-susceptible zone.
 - b. Liquefaction potential maps. Answer to F-3 is 'yes' if site is in a liquefaction potential zone. Answer is 'no' if in a low or null potential zone.
 - c. Liquefaction potential index (LPI) maps. Answer to F-3 is 'yes' if site is has mapped LPI ≥ 5 and no if mapped LPI < 5 .
3. If the location of the site has not been mapped, Question F-3 can be answered as 'yes' if other local information suggests liquefaction potential and 'no' if such information suggests no such hazards.
4. If no maps are available and no information on site conditions is available, answer question F-2 as 'no'.

<http://myplan.calema.ca.gov>

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December 2012

Regional Seismic Hazard Score

F. Regional Seismic Hazard Score

		Ground Shaking Points	Ground Failure Points
F-1	Enter points for shaking hazard potential for location of dwelling (from Table 1). [4]	0	2
F-2	Are ground failure hazards to be looked up using Tables 2, 3, and 4? yes, go to F-3. no, proceed to F-6 and enter 4.0 points for ground failure hazards	2, 4	3
F-3	Is this dwelling located in a liquefaction zone (from Table 2) or landslide zone (from Table 3)? yes, go to F-4. no, go to F-5.	6, 8	4
F-4	Proceed to F-6 and enter ground failure hazard points in accordance with the following table:	F-5 Is the dwelling located in a fault rupture zone (from Table 4)? yes [2] no [0]	
		F-6 Total ground failure points from F-2, F-4, or F-5 (no summation). [2]	
		Total Seismic Hazard Score (Sum of F-1 and F-6) [6]	

Seismic Performance Grade

G. Determination of Seismic Performance Grade

1. Structural Score	<u>Penalty Sum</u>	4. Anticipated Seismic Performance ¹
a. Foundation (Section A)	[11.1]	Following anticipated seismic events: ²
b. Superstructure Framing and Configuration (Section B)	[27.3]	Grade A, A-: Excellent Performer (Potential minor structural and finish damage, earthquake damage ratio ³ of 0%-10%, continued occupancy is likely)
c. General Condition Assessment	[1.8]	Grade B, B+, B-: Good Performer (Potential moderate structural and finish damage, continued occupancy likely following minor structural repairs, earthquake damage ratio ³ of 0%-50%, seismic retrofit measures are encouraged)
d. Nonstructural Elements, Age, and Size (Section D)	[6.0]	Grade C, C+, C-: Fair Performer (Potential moderate to major structural and finish damage, structural repairs may be required prior to continued occupancy, earthquake damage ratio ³ of 10%-60%, seismic retrofit measures are strongly encouraged)
e. Local Site Conditions (Section E)	[3.3]	Grade D, D+, D-: Poor Performer (Potential severe structure and finish damage requiring significant repairs prior to re-occupancy, earthquake damage ratio ³ of 20% – 100%, significant seismic retrofit measures are strongly encouraged)
Total Penalty Points (a to e):	50.5	
Structural Score = (100 – Total Penalty points from line above):	49.5	
2. Seismic Hazard Score (from Section F):	6	
3. Seismic Performance Grade (from Table 5) Note: insert this grade, including + or -, if applicable in box on page 1		

Seismic Performance Grade

Table 5. Seismic Performance Grade Based on Structural Score and Regional Seismic Hazard Score

Seismic Hazard Score		0 - 1	2 - 3	4 - 5	6 - 7	8 - 10	11 - 12
Structural Score	1.0 - 45.9	B-	C+	C	D	D-	D-
	46.0 - 64.9	B+	B	C+	D+	D	D-
	65.0 - 74.9	A-	B+	B	C	C-	D+
	75.0 - 84.9	A-	A-	B+	B-	C	C
	85.0 - 100	A	A	A-	B+	B	B-

Seismic Performance Grade

G. Determination of Seismic Performance Grade

1. Structural Score	<u>Penalty Sum</u>	4. Anticipated Seismic Performance ¹
a. Foundation (Section A)	[11.1]	Following anticipated seismic events: ²
b. Superstructure Framing and Configuration (Section B)	[27.3]	Grade A, A-: Excellent Performer (Potential minor structural and finish damage, earthquake damage ratio ³ of 0%-10%, continued occupancy is likely)
c. General Condition Assessment	[1.8]	Grade B, B+, B-: Good Performer (Potential moderate structural and finish damage, continued occupancy likely following minor structural repairs, earthquake damage ratio ³ of 0%-50%, seismic retrofit measures are encouraged)
d. Nonstructural Elements, Age, and Size (Section D)	[6.0]	Grade C, C+, C-: Fair Performer (Potential moderate to major structural and finish damage, structural repairs may be required prior to continued occupancy, earthquake damage ratio ³ of 10%-60%, seismic retrofit measures are strongly encouraged)
e. Local Site Conditions (Section E)	[3.3]	Grade D, D+, D-: Poor Performer (Potential severe structure and finish damage requiring significant repairs prior to re-occupancy, earthquake damage ratio ³ of 20% – 100%, significant seismic retrofit measures are strongly encouraged)
Total Penalty Points (a to e):	50.5	
Structural Score = (100 – Total Penalty points from line above):	49.5	
2. Seismic Hazard Score (from Section F):	6	
3. Seismic Performance Grade (from Table 5) Note: insert this grade, including + or -, if applicable in box on page 1	D+	

Improving the Structural Score

Item	Retrofit Description	Points (circle applicable number)	Priority Retrofit
A-1	Provide continuous reinforced concrete foundation	4.2	
A-3	Provide foundation pads under interior posts	1.4	Yes
A-5	Add anchor bolts or retrofit anchors	1.7 4.6 10.0 15.0	Yes
B-2	Add bracing walls at dwelling exterior	3.2	
B-3	Install lighter roofing	1.6 3.5	
B-4	Install plywood/OSB or steel frame at garage front	3.0	Yes
B-5	Change exterior wall finish	1.0 2.5 3.5	
B-8	Improve bracing at perimeter walls below lowest floor	4.0 7.0 14.0	Yes
C-2	Repair cut structural framing	1.5	
C-3	Repair deteriorated stucco	1.0 2.0	
C-4	Repair deteriorated foundation	0.6 1.3	
D-1	Strap exterior chimney to roof and floors	1.0	
D-2	Provide bracing and flexible water and gas connections for water heater	1.0	Yes
D-3	Provide earthquake-activated gas shut-off valves	1.0	Yes
D-4	Anchor exterior stairs, deck and porch roof	1.0	Yes
E-3	Repair footing cracks	1.0 2.7	
E-6	Improve rain water routing away from foundations	1.3 2.6	Yes

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December 2012

Improving the Seismic Performance Grade

Priority Retrofits: For this dwelling, the Structural Score can be increased by as many as 16.4 "Priority Retrofit" points (insert sum of points for circled items in rows with "Yes" in Priority Retrofit column). This will increase Structural Score to 65.9 (Section G, Item 1f Structural Score plus "Priority" retrofit points). This will result in an improved Structural Grade of C (from Table 5, using improved Structural Score).

All Retrofits: For this dwelling, the Structural Score can be increased by as many as 29.3 retrofit points (insert sum of ALL points for circled items). This will increase the Structural Score to 78.8 (Section G, Item 1f structural score plus ALL points circled above). This will result in an improved Structural Grade of B- (from Table 5, using improved Structural Score).

Improving the Seismic Performance Grade

4. Anticipated Seismic Performance¹

Following anticipated seismic events:²

Grade A, A-: Excellent Performer

(Potential minor structural and finish damage, earthquake damage ratio³ of 0%-10%, continued occupancy is likely)

Grade B, B+, B-: Good Performer

(Potential moderate structural and finish damage, continued occupancy likely following minor structural repairs, earthquake damage ratio³ of 0%-50%, seismic retrofit measures are encouraged)

Grade C, C+, C-: Fair Performer

(Potential moderate to major structural and finish damage, structural repairs may be required prior to continued occupancy, earthquake damage ratio³ of 10%-60%, seismic retrofit measures are strongly encouraged)

Grade D, D+, D-: Poor Performer

(Potential severe structure and finish damage requiring significant repairs prior to re-occupancy, earthquake damage ratio³ of 20% – 100%, significant seismic retrofit measures are strongly encouraged)

Communication With Homeowner

Qualitative:

- Overall seismic performance - excellent, good, fair or poor.
- Anticipated level of structural damage - minor, moderate, moderate to major, and severe. The likelihood of finish damage is noted at all grades.
- Likelihood of continued occupancy - likely but not certain, following post-earthquake inspection and minor repairs, following structural repairs, and following significant structural repairs.
- Seismic retrofit encouraged

Basis: expert opinion, limited earthquake damage data, pilot study

Communication With Homeowner

Quantitative:

- Damage ratio – cost of repair as a function of replacement cost
 - Grade A - 0% to 10%
 - Grade B - 0% to 50%
 - Grade C - 10% to 60%
 - Grade D - 20% to 100%

Basis: EQECAT loss estimation study

Communication With Homeowner

EQECAT Study:

- 76 dwelling models, grades A to D-
- 100 dwelling sites covering range of ground shaking hazard
- Range of seismic events deemed credible by USGS, tied to basis for seismic hazard maps
- 500 year losses (1 in 500 chance of exceedance in year)
- Described to homeowner as event from which they may have to recover

Next Steps

- Convince stakeholders to invest in retrofit
 - Homeowners
 - Insurers – rate adjustment or rebate?
 - Government – mandate? incentives including rebate?
 - Lenders?
- Must provide confidence that retrofit work will result in improved performance suggested by grade descriptions

Future Needs

- Further confirmation, development of damage ratios, expanding on current limited study, narrow range of ratios

Grade B, B+, B-: Good Performer

(Potential moderate structural and finish damage, continued occupancy likely following minor structural repairs, earthquake damage ratio³ of 0%-50%, seismic retrofit measures are encouraged)

Grade C, C+, C-: Fair Performer

(Potential moderate to major structural and finish damage, structural repairs may be required prior to continued occupancy, earthquake damage ratio³ of 10%-60%, seismic retrofit measures are strongly encouraged)

Grade D, D+, D-: Poor Performer

(Potential severe structure and finish damage requiring significant repairs prior to re-occupancy, earthquake damage ratio³ of 20% – 100%, significant seismic retrofit measures are strongly encouraged)

Future Needs

- Seismic retrofit guidance that will:
 - Address all assessment items
 - Provide consistent performance objective
 - Written in mandatory code language
 - Provide rigorous minimum requirements
 - Is rigorously linked to improvement in building performance and reduction in damage ratio

Limits of the Methodology

- Due to limits of assessment, performance for an assigned grade could vary widely
- Dwelling construction is inherently variable
- Limited portions of the structure are visible without removing finish materials
- Variability is inherent in seismic hazard
- Owner could choose to perform a more detailed assessment to increase level of knowledge

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Questions, Comments?

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