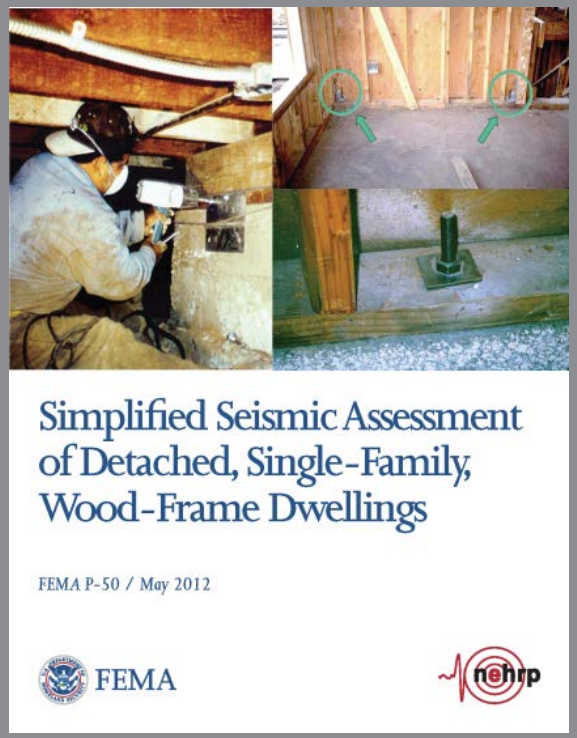
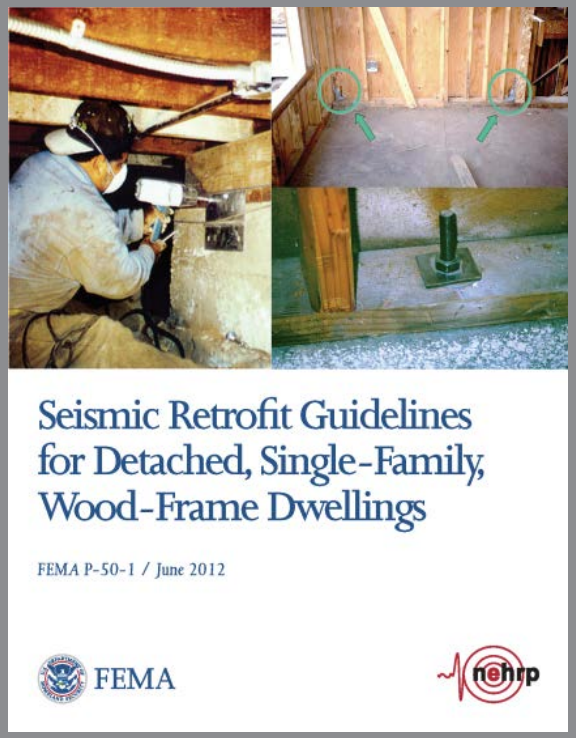
FEMA P-50 and P-50-1 Simplified Assessment and Seismic Retrofit Guidelines





Kelly Cobeen, Wiss Janney Elstner & Associates

Northridge 20 Symposium - January 17, 2014

Casualties: 24 of the 25 fatalities in the Northridge Earthquake that were caused by building damage occurred in woodframe buildings (1)

Property Loss: Half or more of the $40 billion in property damage was due to damage to wood buildings; approximately. $15 billion in insured loss (2)

Functionality: 48,000 housing units, almost all of them in woodframe buildings, were rendered uninhabitable by the earthquake (3)

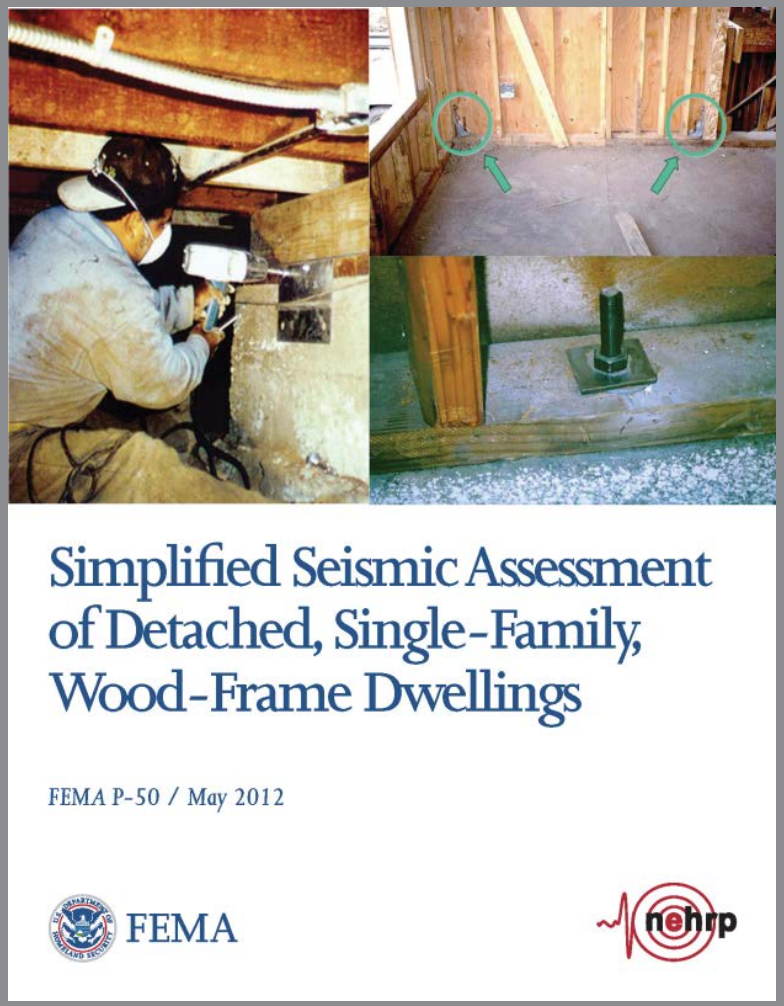
(1) EQE and Calif. OES, 1995
(2) Charles Kircher et al., 1997, and Robert Reitherman, 1998
(3) Jeanne B. Perkins, et al., 1998

Past Practice

- Seismic retrofit of dwellings is usually voluntary
- Retrofit is encouraged, but not widely implemented
- Standardized methods of evaluating vulnerability have not existed
- Retrofit objective is related to damage reduction, without discussion of resulting building performance

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



Assessment Form

FEMA P-50 **Simplified Seismic Assessment Form For Detached, Single-Family, Wood-Frame Dwellings**
(Please print all information)

Grade

Street Address | Community/Area/City | ZIP Code | Date

Owner | Inspector | Inspection Form # (optional)

For each question, circle only one answer. Circle the one with higher penalty if more than one answer applies. Exception: question B-1

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. 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]

		Penalty
*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 bolt 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	

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

Assessment Form

Allow you to:

- Assign a Seismic Performance Grade

D+

Assessment Form

Allow you to:

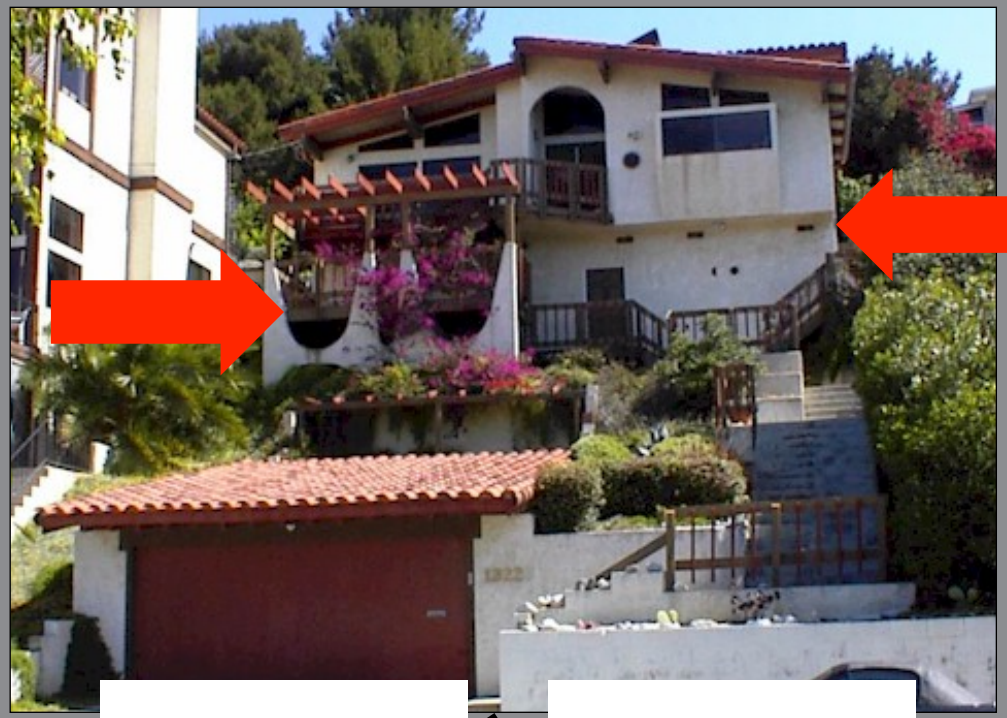
- Assign a Seismic Performance Grade
- Identify seismic retrofit opportunities & priorities

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 sh	
*A-1 The exterior footing is:	
a. continuous concrete or reinforced masonry	[0]
b. other footing conditions	[4.2]

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 to1 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]

Structural Score

*B-4 For an attached garage with a second floor above, the narrow walls at the side of the garage door openings have:

a. wood structural panels on each narrow wall pier [0]

b. structural steel frames around or alongside the door [0]

c. prefabricated narrow shear walls, installed in accordance with manufacturer's recommendations [0]

d. none of the conditions specified in conditions a, b, or c above is visible [3.0]

e. not applicable (single story) or built in accordance with 1997 UBC, 2000 IBC, 2000 IRC or later edition [0]

Structural Score

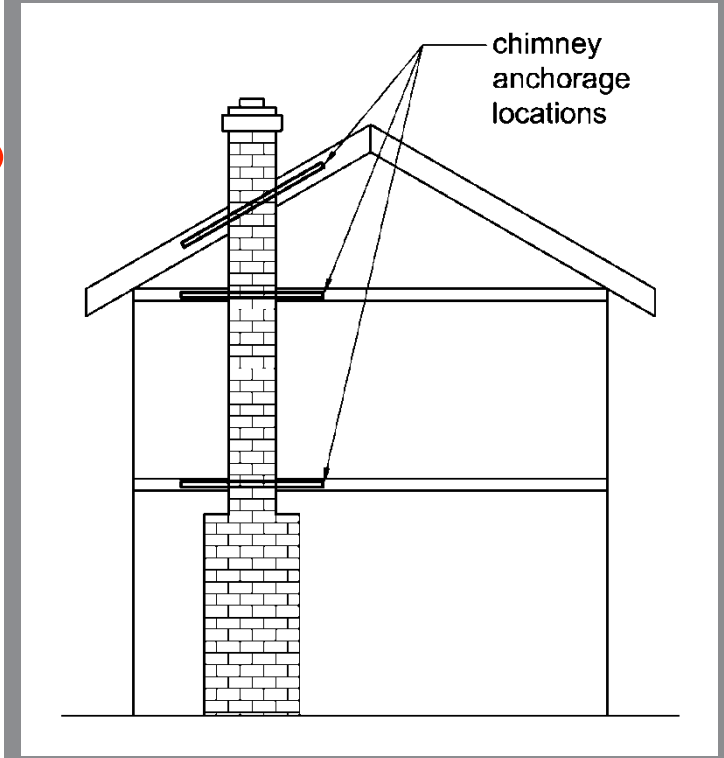
*C-3:	There is evidence of: stucco detachment, bowing of stucco, corroded wire mesh, extensive cracking at finished grade above the bottom of the stucco:	a. extensive	[2.0]
		b. minor	[1.0]
		c. none	[0]

Structural Score

D. Nonstructural Elements, Age, and Size

		Penalty
*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]

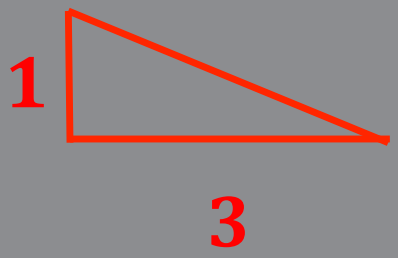
*Assessment item that may be improved by seismic retrofit; **see pag**

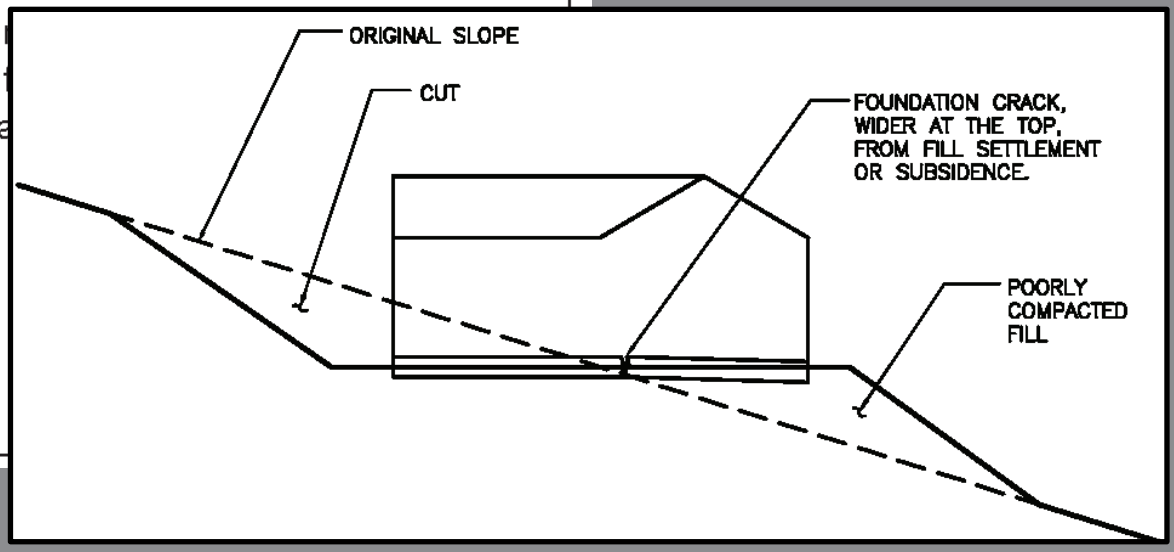


Structural Score

E. Local Site Conditions

		Penalty
E-1	The dwelling is located primarily on:	
	a. a flat lot or slope (≤ 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 *not* on cut-and-fill pad	[0]
*E-3	The exterior concrete footi	
	a. no visible cracks or a	
	b. minor cracks in severa	
	c. extensive cracking	
	d. not applicable	





Seismic Performance Grade

G. Determination of Seismic Performance Grade

		Penalty Sum
1.	**Structural Score**	
a.	Foundation (Section A)	[11.1]
b.	Superstructure Framing and Configuration (Section B)	[27.3]
c.	General Condition Assessment	[1.8]
d.	Nonstructural Elements, Age, and Size (Section D)	[6.0]
e.	Local Site Conditions (Section E)	[3.3]
	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):	
3.	**Seismic Performance Grade** (from Table 5) Note: insert this grade, including + or -, if applicable in box on page 1	

4. Anticipated Seismic Performance[1]

Following anticipated seismic events:[2]

Grade A, A-: Excellent Performer
(Potential minor structural and finish damage, earthquake damage ratio[3] 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 ratio[3] 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 ratio[3] 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 ratio[3] of 20% – 100%, significant seismic retrofit measures are strongly encouraged)

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

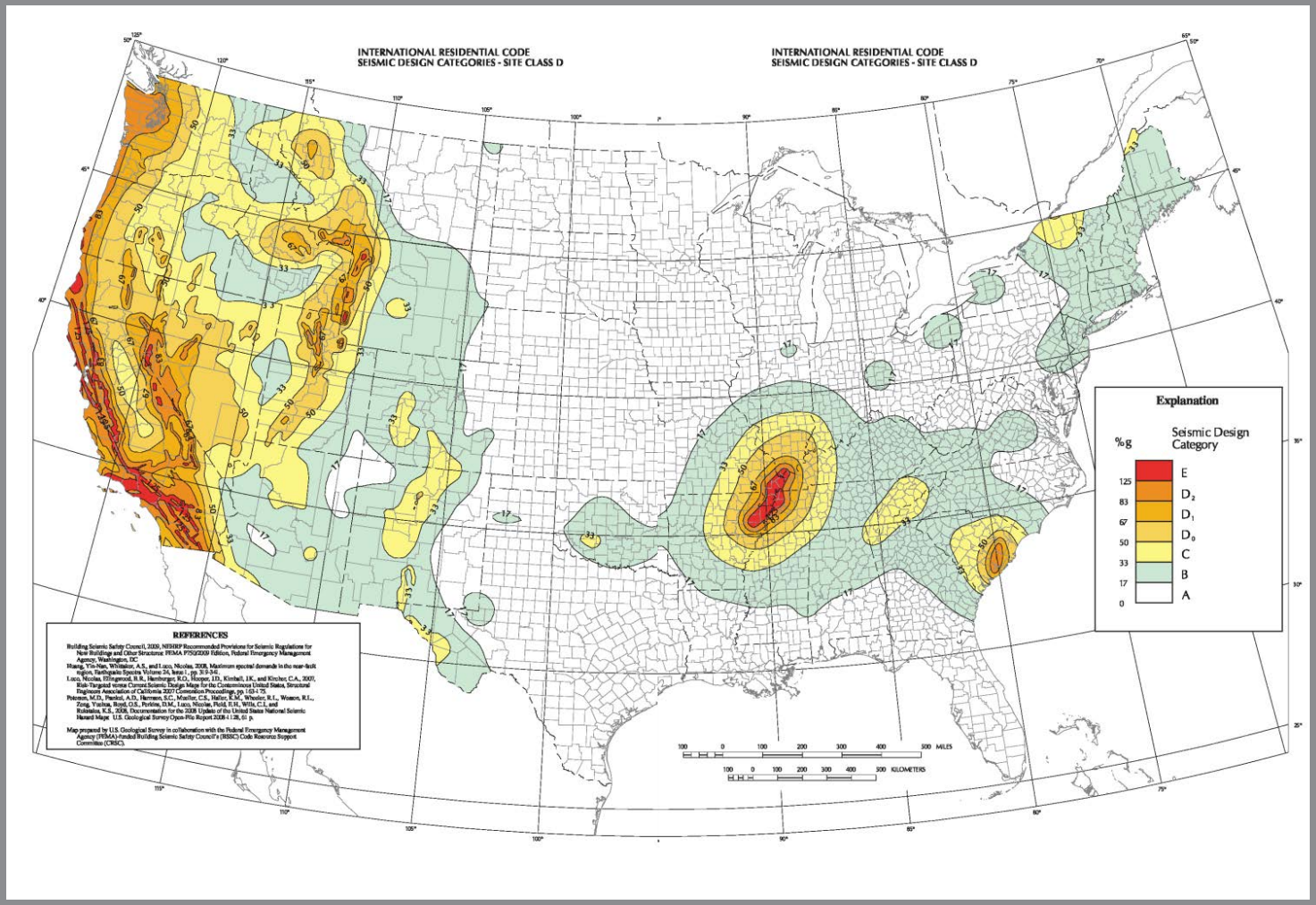
2. Using the value from 1g, assign ground shaking points according to the following table (these points are assigned in Item F-1):

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

[1]Note: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



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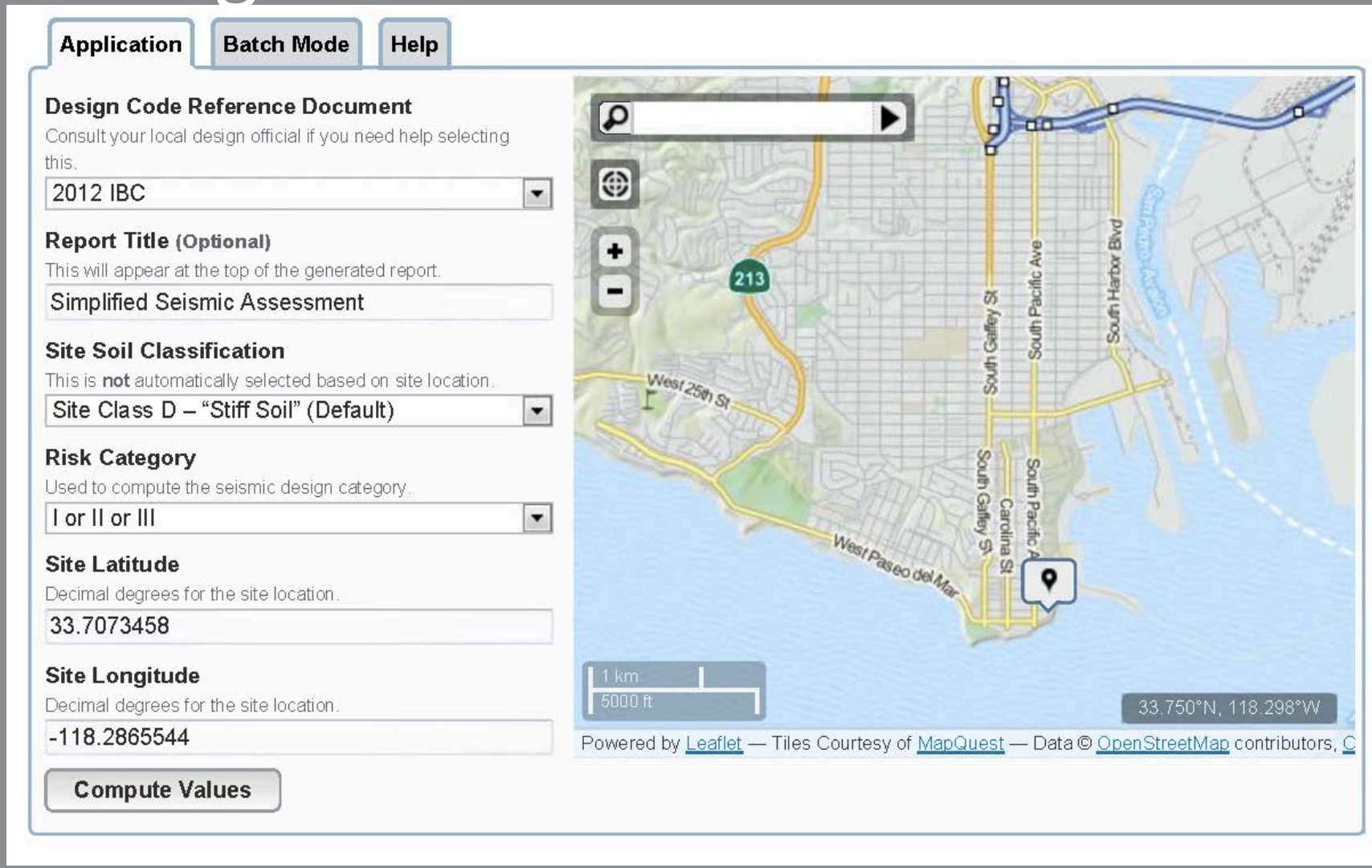
Regional Seismic Hazard Score



Regional Seismic Hazard Score

USGS Design Maps Summary Report

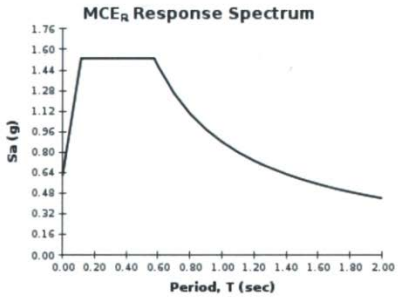
User–Specified Input

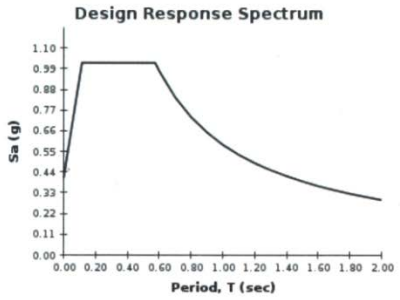
Report Title	Simplified Seismic Assessment Fri October 25, 2013 22:05:13 UTC
Building Code Reference Document	2012 International Building Code (which utilizes USGS hazard data available in 2008)
Site Coordinates	33.70735°N, 118.28655°W
Site Soil Classification	Site Class D – "Stiff Soil"
Risk Category	I/II/III

USGS–Provided Output

S_S =	1.531 g	S_{MS} =	1.531 g	S_{DS} =	1.021 g
S_1 =	0.586 g	S_{M1} =	0.880 g	S_{D1} =	0.586 g

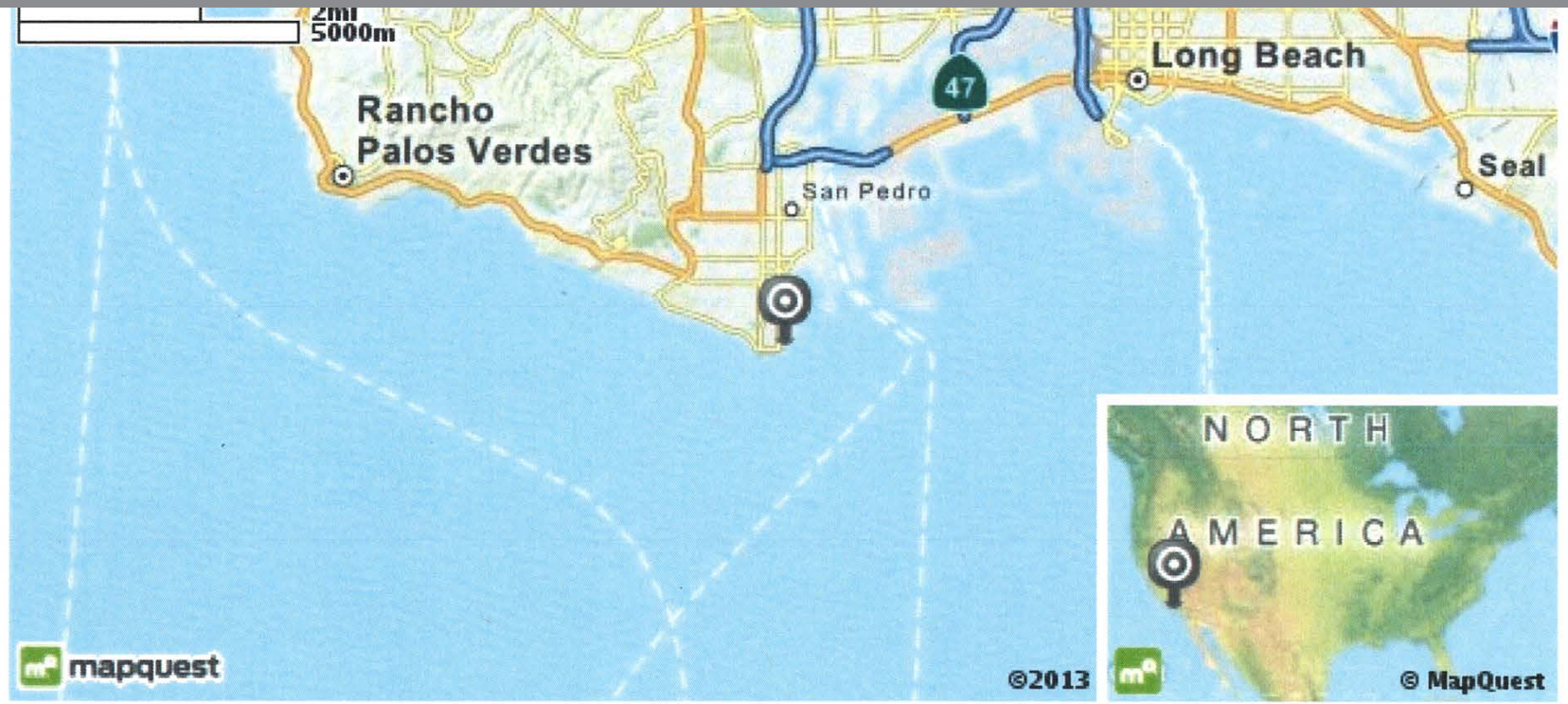
For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.





Although this information is a product of the U.S. Geological Survey, we provide no warranty, expressed or implied, as to the accuracy of the data contained therein. This tool is not a substitute for technical subject-matter knowledge.

Regional Seismic Hazard Score



USGS–Provided Output

S_S =	1.531 g	S_{MS} =	1.531 g	S_{DS} =	1.021 g
S_1 =	0.586 g	S_{M1} =	0.880 g	S_{D1} =	0.586 g

Regional Seismic Hazard Score

Table 1. Assignment of Ground Shaking Hazard Score

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   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: **1.02** g
   g. Multiply value from 1f by 100: **102** %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

[1]Note: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."

Regional Seismic Hazard Score

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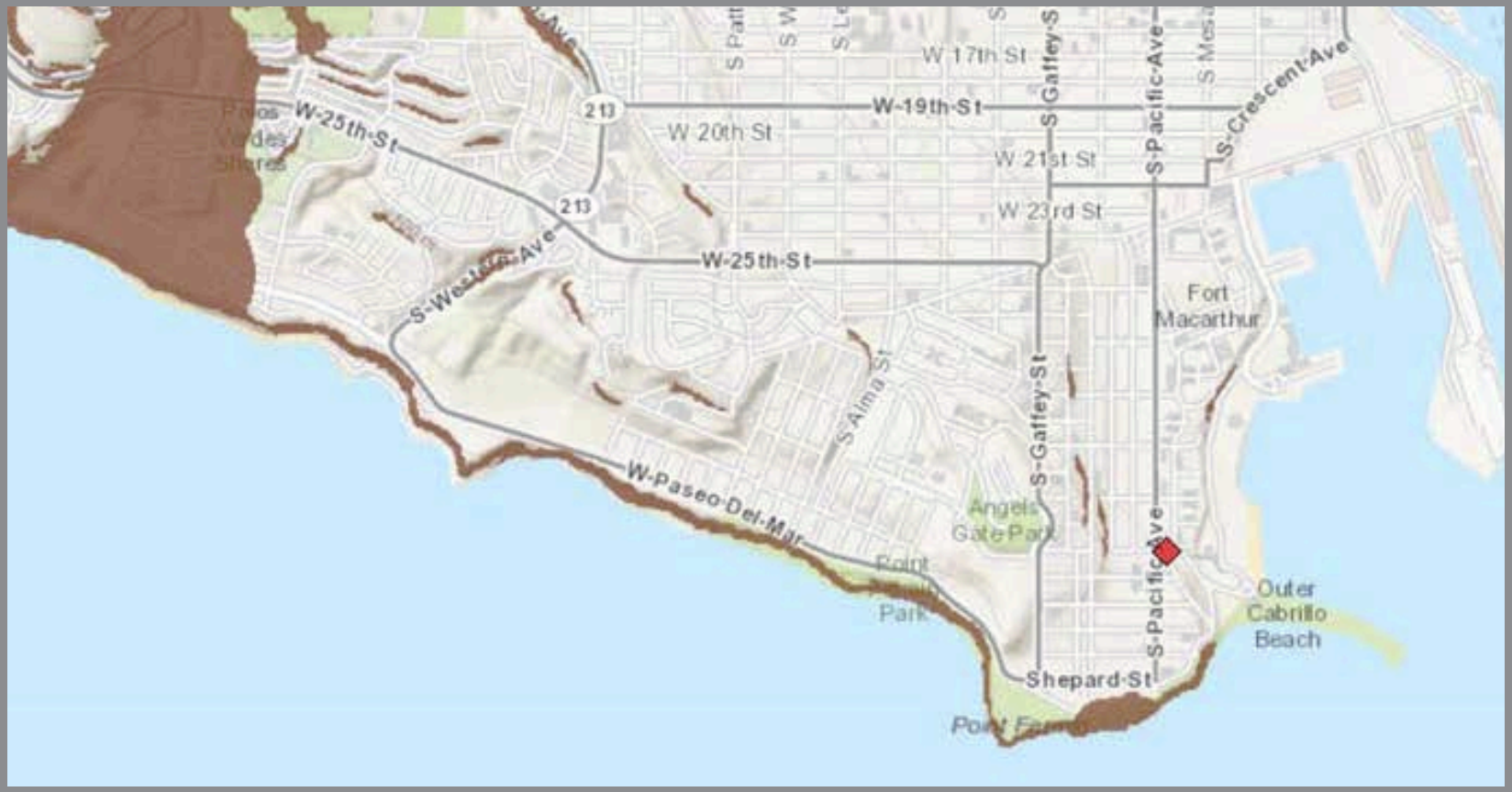
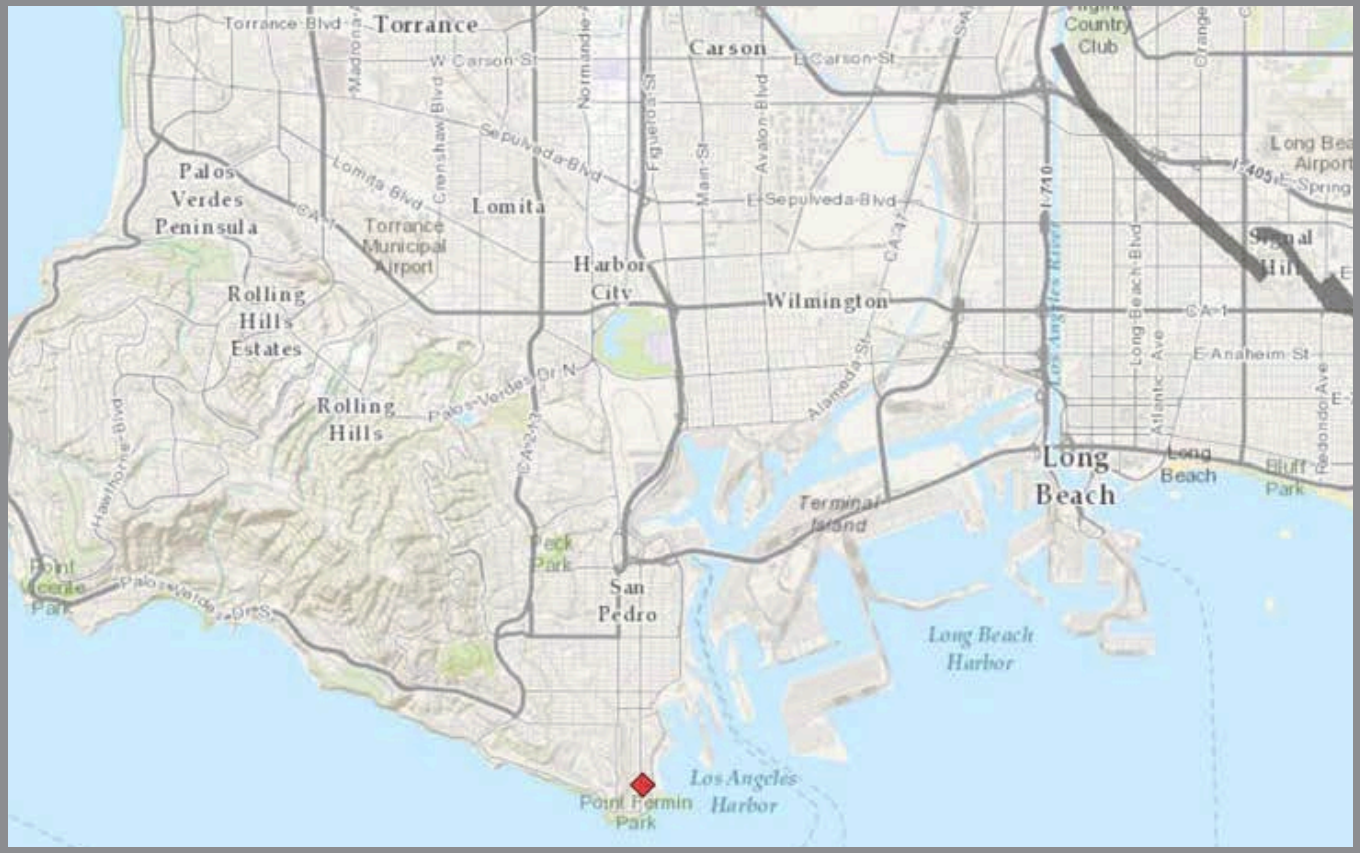
Regional Seismic Hazard Score

Regional Seismic Hazard Score



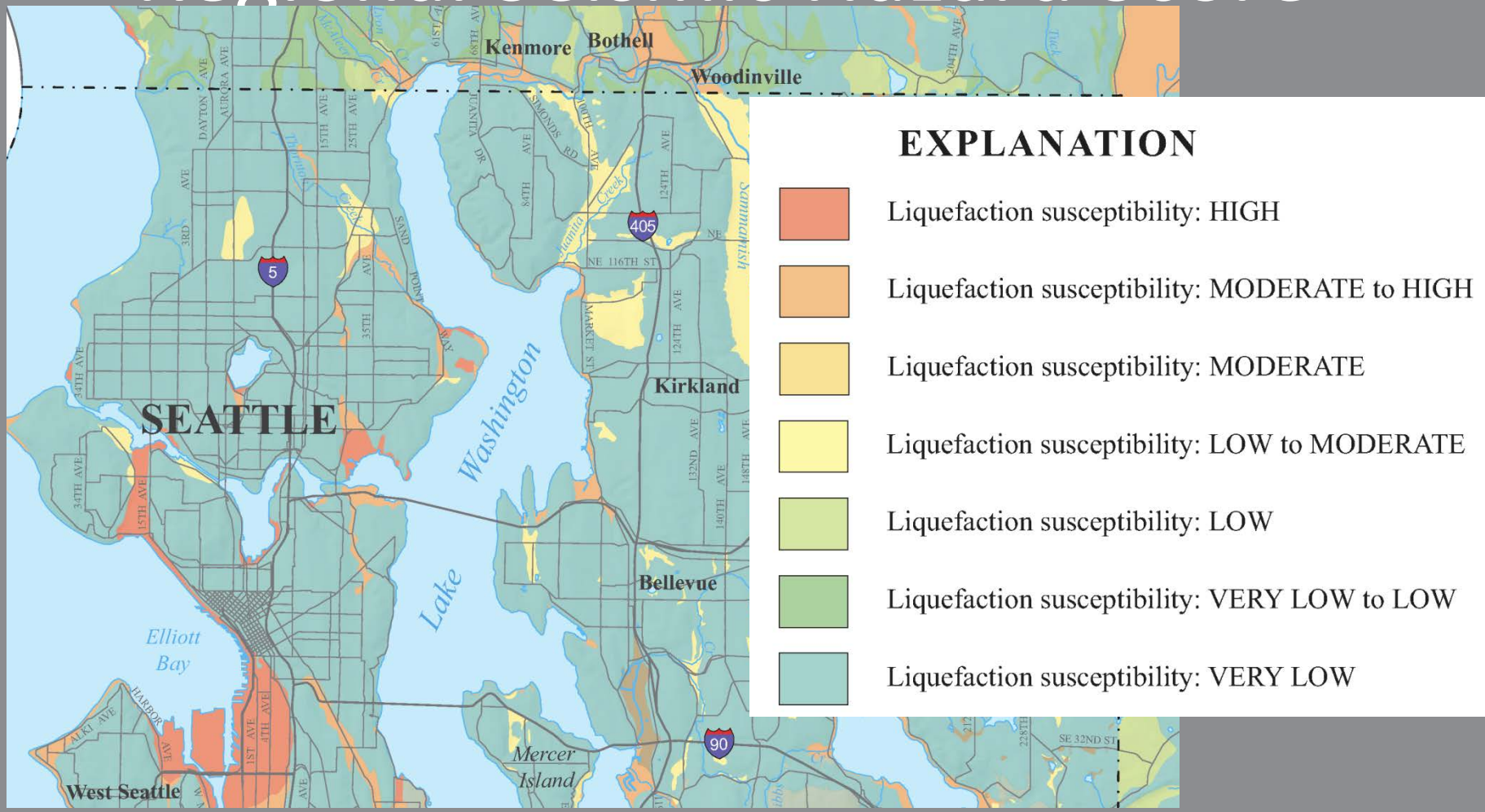
http://myplan.calema.ca.gov

Regional Seismic Hazard Score



http://myplan.calema.ca.gov

Regional Seismic Hazard Score



Regional Seismic Hazard Score

F. Regional Seismic Hazard Score

F-1 Enter points for shaking hazard potential for location of dwelling (from Table 1). [4]

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). [2]

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

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

		Penalty Sum
1.	**Structural Score**	
a.	Foundation (Section A)	[11.1]
b.	Superstructure Framing and Configuration (Section B)	[27.3]
c.	General Condition Assessment	[1.8]
d.	Nonstructural Elements, Age, and Size (Section D)	[6.0]
e.	Local Site Conditions (Section E)	[3.3]
	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+

4. Anticipated Seismic Performance[1]

Following anticipated seismic events:[2]

Grade A, A-: Excellent Performer
(Potential minor structural and finish damage, earthquake damage ratio[3] 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 ratio[3] 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 ratio[3] 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 ratio[3] of 20% – 100%, significant seismic retrofit measures are strongly encouraged)

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

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 Performance[1]

Following anticipated seismic events:[2]

Grade A, A-: Excellent Performer
(Potential minor structural and finish damage, earthquake damage ratio[3] 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 ratio[3] 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 ratio[3] 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 ratio[3] of 20% – 100%, significant seismic retrofit measures are strongly encouraged)

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

P-50-1 Seismic Retrofit Guidelines

Allow you to:

- Select seismic retrofit measures
- Implement seismic retrofit measures
- Regrade a retrofitted house
- Implement a detailed seismic evaluation to replace a simplified evaluation

Future Needs

Goal: To develop a tool to encourage the seismic retrofitting of residential structures, thereby reducing future earthquake losses

- Technical development
- Implementation
- Quality control

Future Needs – Technical Development

- Further confirmation, development of damage loss 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 ratio[3] 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 ratio[3] 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 ratio[3] of 20% – 100%, significant seismic retrofit measures are strongly encouraged)

Future Needs – Technical Development

- When do vulnerabilities become of elevated concern?
- Effective retrofit methods
- Cost-to benefit ratios
- High and low priority retrofits

Future Needs – Implementation

- Champions at every level
- Strategies for implementation
- Tools for communication, public awareness
- Screening tools to quickly identify vulnerabilities of concern
- Simplified design tools to quickly and effectively identify retrofit solutions

Future Needs – Quality Control

- Education of all persons involved
  - Assessors
  - Building departments
  - Retrofit contractors
  - Inspectors
- Quality control programs

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Questions, Comments?