FEMA P-50 Project
Simplified Seismic Assessment Procedures for Detached, Single-Family, Light-Frame Dwellings for Nationwide Use

Ronald T. Eguchi

ImageCat, Inc.

Northridge 20 Symposium

UCLA

January 16-17, 2014

FEMA P-50 Project and P-50-1 Simplified Seismic Assessment and Seismic Retrofit Guidelines for Detached, Single-Family, Wood-Frame Dwellings

Kelly Cobeen

Wiss, Janney, Elster Associates, Inc.

At 1:30 pm in Wood-Frame and Soft Story Buildings Session

Why was the original study (ATC-50) done?

- The Northridge Earthquake exposed serious deficiencies in single-family, wood-frame construction

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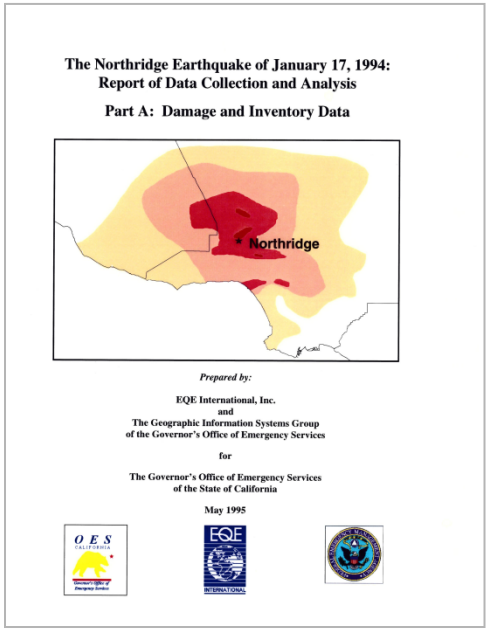
- The Northridge Earthquake exposed serious deficiencies in single-family, wood-frame construction
- $40 B (1994) total loss, much of it due to damage to residential buildings



The Northridge Earthquake of January 17, 1994:
Report of Data Collection and Analysis

Part A: Damage and Inventory Data

Prepared by:

EQE International, Inc.
and
The Geographic Information Systems Group
of the Governor's Office of Emergency Services

for

The Governor's Office of Emergency Services
of the State of California

May 1995

Other Reasons

- The need for such a study was identified well before the Northridge earthquake - Financial Services Subcommittee of the City of Los Angeles' Mayor's Blue Ribbon Panel for Seismic Hazard Reduction
- There lacked a standardized procedure for quantifying the vulnerability of wood-frame structures using an analysis of component performance

Background

- FEMA P-50 is an update of ATC-50, *Simplified Seismic Assessment of Detached, Single-Family, Wood-Frame Dwellings*
- Initial FEMA grant (ATC-50) awarded after the 1994 Northridge earthquake to the City of Los Angeles
- Project included an extensive calibration & validation program that involved 500 evaluations and 50 retrofits

FEMA P-50 Products

- Two products:
  - FEMA P-50: *Simplified Seismic Assessment of Detached, Single-Family, Wood-Frame Dwellings*
  - FEMA P-50-1: *Seismic Retrofit Guidelines for Detached, Single-Family, Wood-Frame Dwellings*

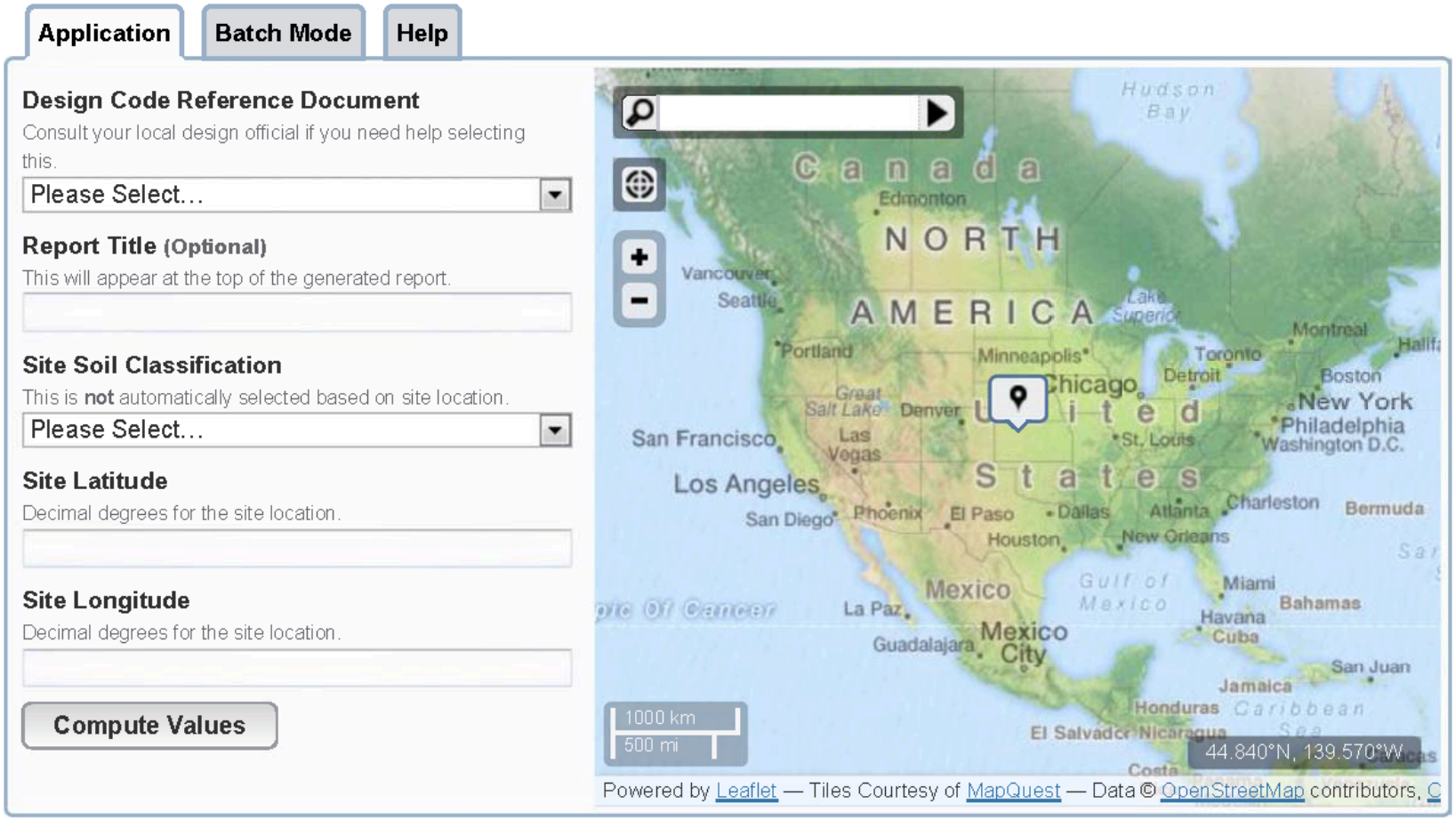
FEMA P-50 Core Team

- Tom McLane (Project Manager), ATC
- Ron Eguchi (Project Technical Director), ImageCat, Inc.
- Kelly Cobeen, Wiss Janney Elstner Associates, Inc.
- Doug Hohbach, Hohbach-Lewin, Structural Engineers
- Nico Luco, U. S. Geological Survey
- Jon Stewart, UCLA
- Chuck Real, California Geological Survey

Enhancements

- A thorough review and update of the structural scoring system for nationwide use
- Updated seismic hazard scoring using online hazard maps for shaking, liquefaction and landslide
- Calibrating damage ranges for each grade based on CEA modeling information and data (EQECAT WORLDCAT Enterprise model)
- Update of seismic rehabilitation guidelines

Regional Seismic Hazard Score



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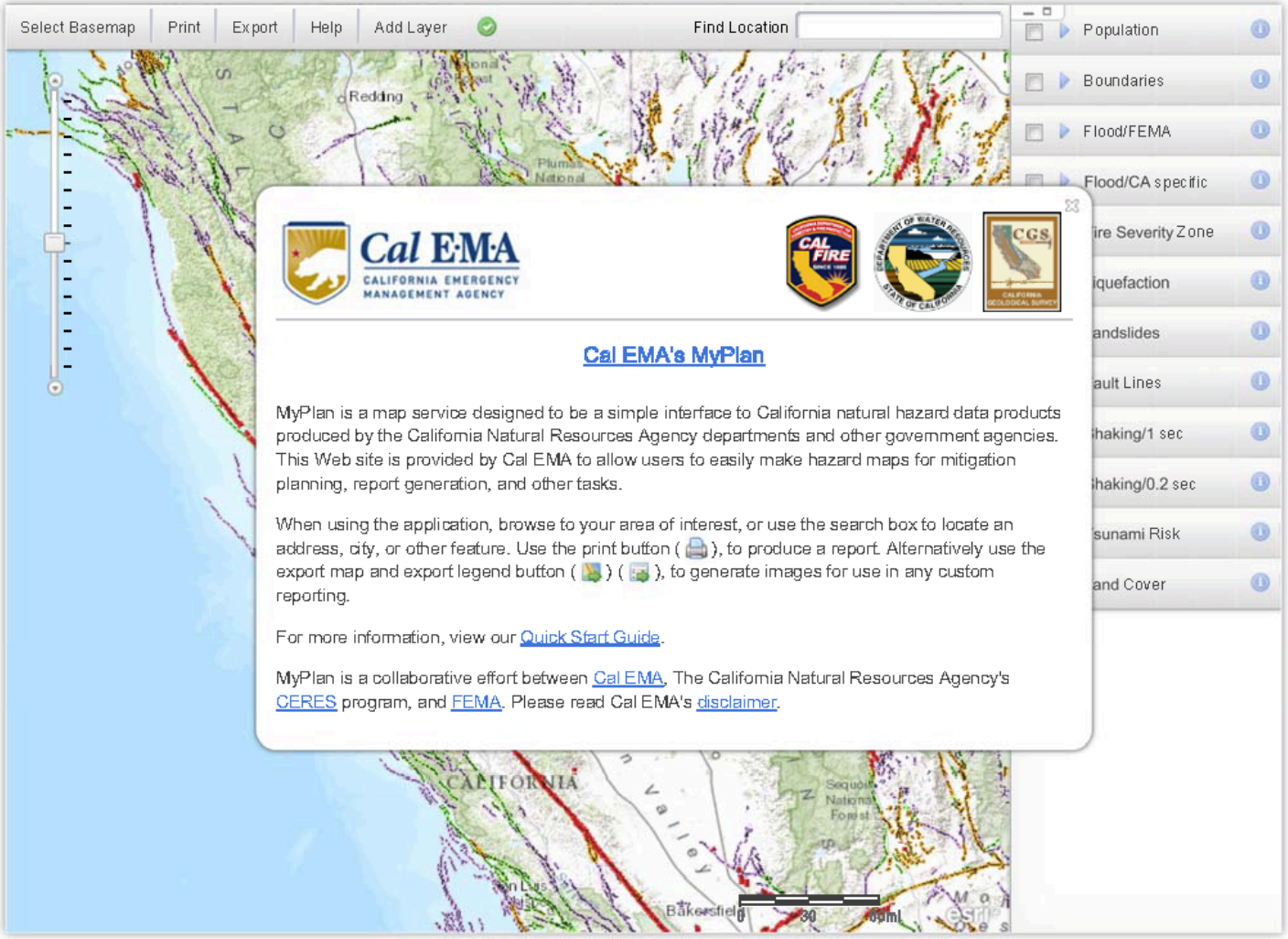


Detailed Analysis performed by EQECAT

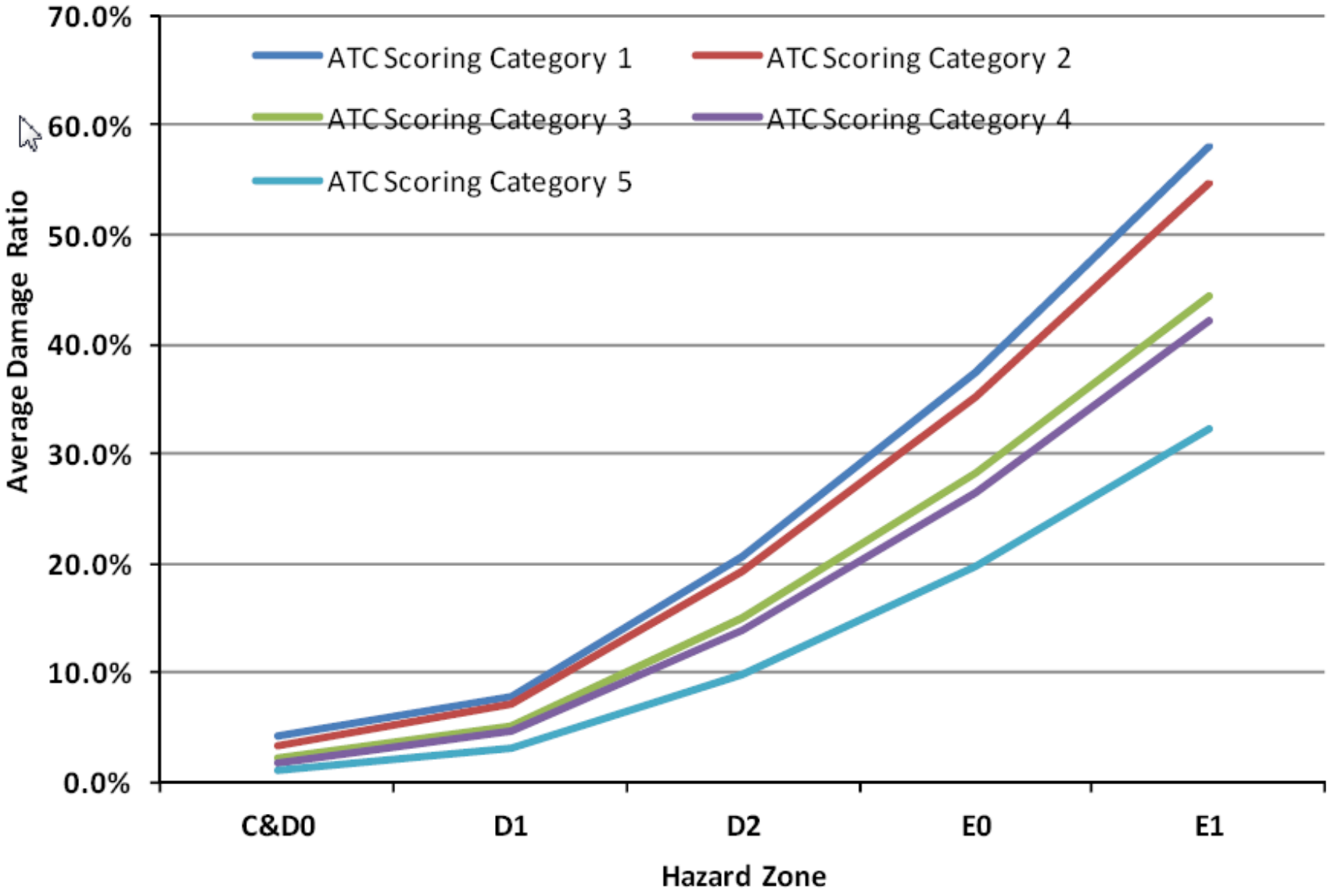
Table D-4 500-year Return Period Damage Ratio Variation Within Each Structural Score and Regional Hazard Score*

Seismic Hazard Score		*0-1*	*2-3*	*4-5*	*6-7*	*8-10*	*11-12*
Structural Score	**1.0-45.9**	**4.1%** (0.6% - 11%)	**7.8%** (1.8% - 15.1%)	**20.7%** (8.7% - 31.5%)	**37.5%** (16.4% - 62.8%)	**58.2%** (33.6% - 79.8%)	N/A
	46.0-64.9	**3.3%** (0.3% - 11%)	**7.1%** (1.3% - 15.1%)	**19.2%** (7.3% - 31.5%)	**35.2%** (14.2% - 62.8%)	**54.8%** (29.4% - 79.8%)	N/A
	65.0-74.9	**2.2%** (0.2% - 7.4%)	**5.1%** (1.1% - 10.8%)	**14.9%** (6.3% - 23.7%)	**28.2%** (12.4% - 48.8%)	**44.4%** (26.2% - 61.6%)	N/A
	75.0-84.9	**1.8%** (0.1% - 6.7%)	**4.7%** (0.8% - 10.4%)	**13.8%** (5.0% - 22.8%)	**26.5%** (10.1% - 48.2%)	**42.2%** (21.8% - 61.6%)	N/A
	85.0-100	**1.1%** (0.1% - 5.4%)	**3.1%** (0.5% - 8.2%)	**9.7%** (3.4% - 19.0%)	**19.7%** (7.5% - 40.1%)	**32.2%** (16.4% - 51.6%)	N/A

*Average Damage Ratio (Minimum Damage Ratio – Maximum Damage Ratio)

Table D-1 Summary of Prototype Structures

Structural Scoring Category	*Structural Score Range*	*No. of Prototype Structures*	*Average Structural Score*
1	1.0 – 45.9	12	39.1
2	46.0 – 64.9	16	58.6
3	65.0 – 74.9	16	70.7
4	75.0 – 84.9	16	78.8
5	85.0 - 100	16	93.0


70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
Average Damage Ratio
ATC Scoring Category 1
ATC Scoring Category 2
ATC Scoring Category 3
ATC Scoring Category 4
ATC Scoring Category 5
C&D0
D1
D2
E0
E1
Hazard Zone

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

FEMA P-50 / May 2012

FEMA

nehrp

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

FEMA P-50 / May 2012

FEMA

nehrp

Seismic Retrofit Guidelines for Detached, Single-Family, Wood-Frame Dwellings

FEMA P-50-1 / June 2012

FEMA

nehrp

Simplified Seismic Assessment Form

- Easy to use and apply (multiple-choice responses)
- Identify seismic deficiencies and establish a Seismic Performance Grade that reflects expected performance in future earthquakes
- Enable inspector to complete evaluation in less than an hour
- Provides list of conditions that, if seismically retrofitted, would enable owner to improve grade

Types of Deficiencies Addressed

- Foundation (e.g., no anchor bolts)
- Superstructure Framing and Configuration (e.g., unsymmetrical wall length)
- General Condition Assessment (e.g., floor out-of-level and wood decay)
- Nonstructural Elements, Age and Size (e.g., un-braced water heaters)
- Local Site Conditions (e.g., cut-and-fill pad w/o geotechnical investigation)
- Regional Seismic Hazards (e.g., evidence of ground failure hazard potential)

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-

1. Structural Score — **Penalty Sum**

a. Foundation (Section A) [ ]

b. Superstructure Framing and Configuration (Section B) [ ]

c. General Condition Assessment [ ]

d. Nonstructural Elements, Age, and Size (Section D) [ ]

e. Local Site Conditions (Section E) [ ]

Total Penalty Points (a to e): ____

Structural Score = (100 – Total Penalty points from line above): ____

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
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	85.0 - 100	A	A	A-	B+	B	B-

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		Penalty Sum
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b.	Superstructure Framing and Configuration (Section B)	[ ]
c.	General Condition Assessment	[ ]
d.	Nonstructural Elements, Age, and Size (Section D)	[ ]
e.	Local Site Conditions (Section E)	[ ]

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Total Penalty Points (a to e): [ ]

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	85.0 - 100	A	A	A-	B+	B	B-

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Improving your score

H. Improving the Seismic Performance Grade

The Structural Score and Seismic Performance Grade may be altered as a result of seismic retrofit or by a more in-depth seismic evaluation of the dwelling and the site by a qualified licensed design professional. Guidance on these issues is provided in Chapter 8.

If seismic retrofit is being considered, the Structural Score could be increased (and the Seismic Performance Grade potentially increased) by retrofitting conditions that would allow the elimination or reduction in penalties, if any, for the following items:

Item	Retrofit Description	Points (circle applicable number)	Priority
A-1	Provide continuous reinforced concrete or masonry foundation	4.2	
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	2.5 3.5	
B-8	Improve bracing at perimeter walls	4.0 7.0 14.0	Yes
C-2	Repair cut structural framing	1.5	Yes
C-3	Repair deteriorated stucco	1.0 2.0	Yes
C-4	Repair deteriorated foundation	0.6 1.3	
D-1	Strap exterior chimney to roof and floors	1.1	
D-2	Provide bracing and flexible water and gas connections for water heater	1.3	Yes
D-3	Provide earthquake-activated gas shut-off valves	0.7	Yes
E-3	Repair footing cracks	1.0 2.6	
E-6	Improve rain water routing away from foundations	1.3 2.6	Yes

Priority Retrofits: For this dwelling, the Structural Score can be increased by as many as _____ PRIORITY retrofit points (insert sum of points for circled items indicated as PRIORITY retrofits). This will increase the Improved Priority Structural Score to _____ (Section G, Item 1f Structural Score plus PRIORITY retrofit points circled above). This will result in an Improved Priority Structural Grade of _____ (from Table 5, using Improved Structural Score).

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

Example B.3 Home with Unbraced Cripple Wall

Street Address/ City /State: Los Angeles 90008

This single-story home has a raised floor supported by an unbraced cripple wall. Additionally, the cripple wall is not bolted to the foundation.

ATC-71-3 **Simplified Seismic Assessment Form**
For Detached, Single-Family, Light-Frame Dwellings
(Please print all information)

D-
Grade

Example B3 (Street Address) | Los Angeles (Community/Area/City) | 90008 (ZIP Code) | Date

Owner | Inspector | Inspection Form # (optional)

For each question, circle only one answer. Circle the one with higher penalty if more than on 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.)

*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 **18.7**

B. Superstructure Framing and Configuration: (Every accessible area such as the attic and under-floor area that reveals structural elements must be inspected.)

B-1 The dwelling has: (circle all that apply, a to e)
- a. unsymmetrical wall strength (torsion problems). yes [1.6]
- b. reentrant corners (seen in plan view) yes [0.3]
- c. split-level floor construction yes [2.0]
- d. out-of-plane offsets of more than 4 ft. in exterior walls yes [0.4]
- e. non-orthogonal seismic resisting systems yes [0.6]
- f. none of the above, or built in accordance with 1994 UBC, 2000 IBC, 2000 IRC or later edition yes [0]

*B-2 For exterior walls at the lowest occupied story, the summed length of full story height wall sections (between openings, excluding <2'-8" panels) on any face is less than:
- a. 20% the length of the wall, if a single story yes [3.2]
- b. 25% the length of the wall, if two stories yes [3.2]
- c. 40% the length of the wall, if three stories or more yes [3.2]
- d. none of the above [0]

*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]

*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]

*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]

*Condition that may be improved by seismic rehabilitation; **see page 7, Section H**

ATC-71-3 **Simplified Seismic Assessment Form**
For Detached, Single-Family, Light-Frame Dwellings
(Please print all information)

D-Grade

Example B3 (Street Address) | Los Angeles (Community/Area/City) | 90008 (ZIP Code) | Date

Owner | Inspector | Inspection Form # (optional)

For each question, circle only one answer. Circle the one with higher penalty if more than on 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.)

*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 18.7

B. Superstructure Framing and Configuration: (Every accessible area such as the attic and under-floor area that reveals structural elements must be inspected.)

B-1 The dwelling has: (circle all that apply, a to e)
- a. unsymmetrical wall strength (torsion problems). yes [1.6]
- b. reentrant corners (seen in plan view) yes [0.3]
- c. split-level floor construction yes [2.0]
- d. out-of-plane offsets of more than 4 ft. in exterior walls yes [0.4]
- e. non-orthogonal seismic resisting systems yes [0.6]
- f. none of the above, or built in accordance with 1994 UBC, 2000 IBC, 2000 IRC or later edition yes [0]

*B-2 For exterior walls at the lowest occupied story, the summed length of full story height wall sections (between openings, excluding <2'-8" panels) on any face is less than:
- a. 20% the length of the wall, if a single story yes [3.2]
- b. 25% the length of the wall, if two stories yes [3.2]
- c. 40% the length of the wall, if three stories or more yes [3.2]
- d. none of the above [0]

*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]

*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]

*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]

*Condition that may be improved by seismic rehabilitation; see page 7, Section H

B. Superstructure Framing and Configuration: (Every accessible area such as the attic and under-floor area that reveals structural elements must be inspected.) *(continued)*

B-6 There is evidence of interior remodeling that has removed interior walls: yes [1.0] / no/ not applicable [0]

B-7 The number of stories is:
a. one (1) [0]
b. two (2) [1.8]
c. 3 or more. [3.6]

*B-8 At the dwelling perimeter, the main lowest framed floor is supported on:
a. beam and column (post-and-pier) system with no sheathed exterior walls [14.0]
b. perimeter cripple walls with no plywood or OSB sheathing [14.0]
c. original or retrofitted perimeter cripple walls with plywood or OBS sheathing and that are one story or less in height [1.0]
d. original or retrofitted perimeter cripple walls with plywood or OSB sheathing and that are greater than one story in height [4.0]
e. wood or steel diagonal braces not detailed in accordance with 1997 UBC, 2000 IBC or later edition [7.0]
f. plywood or OSB sheathed perimeter skirt walls that do not extend to and anchor to the foundation [7.0]
g. no perimeter cripple wall [0]

Total 19.7

C. General Condition Assessment

C-1 The overall condition of the dwelling is:
a. good (essentially crack free, no moisture/water intrusion problems) [0]
b. fair (minor wood decay and cracks) [1.0]
c. poor (many cracks on interior and exterior, floor out-of-level and wood decay) [2.1]

*C-2 In the under floor area, there has been structural alteration (e.g. cutting or notching of framing for elec., plumb., mech.) that would affect the performance of the dwelling in an earthquake: yes [1.5] / no [0] / not applicable [0]

*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]

*C-4 At the foundation level, there is:
a. significant deterioration visible (corrosion, material breakdown) [1.3]
b. some deterioration visible [0.6]
c. no deterioration visible [0]

C-5 Throughout the dwelling, the quality of construction appears to be:
good [0.0]
average [0.8]
poor [1.7]

Total 2.4

D. Nonstructural Elements, Age, and Size

*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]

*D-4 The dwelling has exterior stairs, decks or porch roofs, without internal earthquake bracing, that are attached to the dwelling with:
a. two or more connections tying the stair, deck or porch to the dwelling interior framing [0]
b. nails or screws that would be loaded in withdrawal if the stair deck or porch moved away from the dwelling [1.0]
c. other connection configurations [1.0]

D-5 The dwelling was built: (if remodel/added area >50% of total area, use addition date):
a. before 1920 [3.6]
b. 1921 to 1977 [2.4]
c. 1978 to 1993 [1.2]
d 1994 or later [0]

D-6 The approximate total floor area (sq. ft.) of the dwelling and attached garage is:
a. ≤1600. [0]
b. 1601-2500. [1.0]
c. >2501 [2.0]

Total 6.4

*Condition that may be improved by seismic rehabilitation; see page 7, Section H

B. Superstructure Framing and Configuration: (Every accessible area such as the attic and under-floor area that reveals structural elements must be inspected.) *(continued)*

B-6 There is evidence of interior remodeling that has removed interior walls: yes [1.0] / no/ not applicable [0]

B-7 The number of stories is:
a. one (1) [0]
b. two (2) [1.8]
c. three or more. [3.6]

*B-8 At the dwelling perimeter, the main lowest framed floor is supported on:
a. beam and column (post-and-pier) system with no sheathed exterior walls [14.0]
b. perimeter cripple walls with no plywood or OSB sheathing [14.0]
c. original or retrofitted perimeter cripple walls with plywood or OBS sheathing and that are one story or less in height [1.0]
d. original or retrofitted perimeter cripple walls with plywood or OSB sheathing and that are greater than one story in height [4.0]
e. wood or steel diagonal braces not detailed in accordance with 1997 UBC, 2000 IBC or later edition [7.0]
f. plywood or OSB sheathed perimeter skirt walls that do not extend to and anchor to the foundation [7.0]
g. no perimeter cripple wall [0]

Total 19.7

C. General Condition Assessment

C-1 The overall condition of the dwelling is:
a. good (essentially crack free, no moisture/water intrusion problems) [0]
b. fair (minor wood decay and cracks) [1.0]
c. poor (many cracks on interior and exterior, floor out-of-level and wood decay) [2.1]

*C-2 In the under floor area, there has been structural alteration (e.g. cutting or notching of framing for elec., plumb., mech.) that would affect the performance of the dwelling in an earthquake: yes [1.5] / no [0] / not applicable [0]

*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]

*C-4 At the foundation level, there is:
a. significant deterioration visible (corrosion, material breakdown) [1.3]
b. some deterioration visible [0.6]
c. no deterioration visible [0]

C-5 Throughout the dwelling, the quality of construction appears to be:
good [0.0]
average [0.8]
poor [1.7]

Total 2.4

D. Nonstructural Elements, Age, and Size

*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]

*D-4 The dwelling has exterior stairs, decks or porch roofs, without internal earthquake bracing, that are attached to the dwelling with:
a. two or more connections tying the stair, deck or porch to the dwelling interior framing [0]
b. nails or screws that would be loaded in withdrawal if the stair deck or porch moved away from the dwelling [1.0]
c. other connection configurations [1.0]

D-5 The dwelling was built: (if remodel/added area >50% of total area, use addition date):
a. before 1920 [3.6]
b. 1921 to 1977 [2.4]
c. 1978 to 1993 [1.2]
d 1994 or later [0]

D-6 The approximate total floor area (sq. ft.) of the dwelling and attached garage is:
a. ≤1600. [0]
b. 1601-2500. [1.0]
c. >2501 [2.0]

Total 6.4

*Condition that may be improved by seismic rehabilitation; see page 7, Section H

E. Local Site Conditions

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 footing has:
- a. no visible cracks or a few minor cracks [0]
- b. minor cracks in several areas [1.0]
- c. extensive cracking [2.7]
- d. not applicable [0]

E-4 The evidence of differential settlement in or around the dwelling is:
- a. extensive [2.5]
- b. minor [1.0]
- c. none visible [0]

E-5: The slope above or below the structure appears to be unstable
- yes [3.2]
- no [0]
- not applicable [0]

*E-6: General condition of site drainage:
- a. roof gutters and down spouts collecting and conducting water away from foundation [0]
- b. water collecting at/near perimeter footing with no positive slope away from dwelling [2.6]
- c. no roof gutters but drainage appears to be adequate or roof gutters with downspouts that empty into splash blocks [1.3]

Total 2.3

F. Regional Seismic Hazard Score

F-1 Enter points for shaking hazard potential for location of dwelling (from Table 1). [6]

F-2 Are ground failure hazards to be looked up using Tables 2-4?
- Yes, go to F-3.
- No, [4.0]. Proceed to ground failure total (F-6).

F-3 Is this site located in a liquefaction zone (from Table 2) or landslide zone (from Table 3)?
- Yes, go to F-4.
- No [0]. Proceed to F-5.

F-4 This question applies only to sites in liquefaction or landslides zones. The ground shaking score for the site (from F-1) is:
- 0 [2]
- 2, 4 [3]
- 6, 8 [4]

F-5 Is the site located in a fault rupture zone (from Table 4)?
- Yes [2]
- No [0]

F-6 Total ground failure score. Value from F-2, F-3, or larger of F-4 and F-5 (no summation). [4]

Total Seismic Hazard Score (Sum of F-1 and F-6) 10

Table 1. Assignment of ground shaking hazard score

5. Use the USGS Seismic Design Maps Web Application (link)[1] to look up spectral response acceleration S_{DS} in units of g:
   - 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: 1.29 g
   - g. Multiply value from 1e by 100: 129 %g
6. Using the value from 1f, assign ground motion points according to the following table (these points are assigned in Question F-1):

Value of S_{DS} (% g)	Ground Motion 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 will 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."

*Condition that may be improved by seismic rehabilitation; see page 7, Section H

E. Local Site Conditions

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 footing has:
- a. no visible cracks or a few minor cracks [0]
- b. minor cracks in several areas [1.0]
- c. extensive cracking [2.7]
- d. not applicable [0]

E-4 The evidence of differential settlement in or around the dwelling is:
- a. extensive [2.5]
- b. minor [1.0]
- c. none visible [0]

E-5: The slope above or below the structure appears to be unstable
- yes [3.2]
- no [0]
- not applicable [0]

*E-6: General condition of site drainage:
- a. roof gutters and down spouts collecting and conducting water away from foundation [0]
- b. water collecting at/near perimeter footing with no positive slope away from dwelling [2.6]
- c. no roof gutters but drainage appears to be adequate or roof gutters with downspouts that empty into splash blocks [1.3]

Total **2.3**

F. Regional Seismic Hazard Score

F-1 Enter points for shaking hazard potential for location of dwelling (from Table 1). [6]

F-2 Are ground failure hazards to be looked up using Tables 2-4?
- Yes, go to F-3.
- No, [4.0]. Proceed to ground failure total (F-6).

F-3 Is this site located in a liquefaction zone (from Table 2) or landslide zone (from Table 3)?
- Yes, go to F-4.
- No [0]. Proceed to F-5.

F-4 This question applies only to sites in liquefaction or landslides zones. The ground shaking score for the site (from F-1) is:
- 0 [2]
- 2, 4 [3]
- 6, 8 [4]

F-5 Is the site located in a fault rupture zone (from Table 4)?
- Yes [2]
- No [0]

F-6 Total ground failure score. Value from F-2, F-3, or larger of F-4 and F-5 (no summation). [4]

Total Seismic Hazard Score (Sum of F-1 and F-6) **10**

Table 1. Assignment of ground shaking hazard score

5. Use the USGS Seismic Design Maps Web Application (link)[1] to look up spectral response acceleration S_{DS} in units of g:
   - 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: 1.29 g
   - g. Multiply value from 1e by 100: 129 %g
6. Using the value from 1f, assign ground motion points according to the following table (these points are assigned in Question F-1):

Value of S_{DS} (% g)	Ground Motion 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 will 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."

*Condition that may be improved by seismic rehabilitation; see page 7, Section H

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-

G. Determination of Seismic Performance Grade

1. Structural Score

	Penalty Sum
a. Foundation (Section A)	[18.7]
b. Superstructure (Framing and Configuration (Section B)	[19.7]
c. General Condition Assessment	[2.4]
d. Nonstructural Elements, Age, and Size (Section D)	[6.4]
e. Local Site Conditions (Section E)	[2.3]
Total Penalty Points (a to e):	49.5
Structural Score = (100 – Total Penalty points from line above):	50.5

2. Seismic Hazard Score (from Section F): 10

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

Following a moderate to major earthquake[2]:

Grade A, A+, A-: Excellent Performer
(Potential finish damage, minor structural damage, continued occupancy is likely)

Grade B, B+, B-: Good Performer
(Potential finish damage, moderate structural damage, continued occupancy likely following minor structural repairs, seismic retrofit measures are encouraged)

Grade C, C+, C-: Fair Performer
(Potential finish damage, moderate to major structural damage, structural repairs may be required prior to continued occupancy, seismic retrofit measures are strongly encouraged)

Grade D, D+, D-: Poor Performer
(Potential severe damage to finishes and structure requiring significant repairs prior to re-occupancy, seismic retrofit measures are strongly encouraged)

[2]Dwellings are generally anticipated but not certain to have the described performance.

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-

G. Determination of Seismic Performance Grade

1. Structural Score

	Penalty Sum
a. Foundation (Section A)	[18.7]
b. Superstructure (Framing and Configuration (Section B)	[19.7]
c. General Condition Assessment	[2.4]
d. Nonstructural Elements, Age, and Size (Section D)	[6.4]
e. Local Site Conditions (Section E)	[2.3]
Total Penalty Points (a to e):	49.5
Structural Score = (100 – Total Penalty points from line above):	50.5

2. Seismic Hazard Score (from Section F): 10

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

Following a moderate to major earthquake[2]:

Grade A, A+, A-: Excellent Performer
(Potential finish damage, minor structural damage, continued occupancy is likely)

Grade B, B+, B-: Good Performer
(Potential finish damage, moderate structural damage, continued occupancy likely following minor structural repairs, seismic retrofit measures are encouraged)

Grade C, C+, C-: Fair Performer
(Potential finish damage, moderate to major structural damage, structural repairs may be required prior to continued occupancy, seismic retrofit measures are strongly encouraged)

Grade D, D+, D-: Poor Performer
(Potential severe damage to finishes and structure requiring significant repairs prior to re-occupancy, seismic retrofit measures are strongly encouraged)

[2]Dwellings are generally anticipated but not certain to have the described performance.

H. Improving the Seismic Performance Grade

The Structural Score and Seismic Performance Grade may be altered as a result of seismic retrofit or by a more in-depth seismic evaluation of the dwelling and the site by a qualified licensed design professional. Guidance on these issues is provided in Chapter 8.

If seismic retrofit is being considered, the Structural Score could be increased (and the Seismic Performance Grade potentially increased) by retrofitting conditions that would allow the elimination or reduction in penalties, if any, for the following items:

Item	Retrofit Description	Points (circle applicable number)	Priority
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

Priority Retrofits: For this dwelling, the Structural Score can be increased by as many as 31.3 PRIORITY retrofit points (insert sum of points for circled items indicated as PRIORITY retrofits). This will increase Structural Score to 81.8 (Section G, 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 38.6 retrofit points (insert sum of ALL points for circled items). This will increase the Structural Score to 89.1 (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).

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H. Improving the Seismic Performance Grade

The Structural Score and Seismic Performance Grade may be altered as a result of seismic retrofit or by a more in-depth seismic evaluation of the dwelling and the site by a qualified licensed design professional. Guidance on these issues is provided in Chapter 8.

If seismic retrofit is being considered, the Structural Score could be increased (and the Seismic Performance Grade potentially increased) by retrofitting conditions that would allow the elimination or reduction in penalties, if any, for the following items:

Item	Retrofit Description	Points (circle applicable number)	Priority
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

Priority Retrofits: For this dwelling, the Structural Score can be increased by as many as 31.3 PRIORITY retrofit points (insert sum of points for circled items indicated as PRIORITY retrofits). This will increase Structural Score to 81.8 (Section G, 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 38.6 retrofit points (insert sum of ALL points for circled items). This will increase the Structural Score to 89.1 (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).

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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

Priority Retrofits: For this dwelling, the Structural Score can be increased by as many as 31.3 PRIORITY retrofit points (insert sum of points for circled items indicated as PRIORITY retrofits). This will increase Structural Score to 81.8 (Section G, 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 38.6 retrofit points (insert sum of ALL points for circled items). This will increase the Structural Score to 89.1 (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).

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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

Priority Retrofits: For this dwelling, the Structural Score can be increased by as many as 31.3 PRIORITY retrofit points (insert sum of points for circled items indicated as PRIORITY retrofits). This will increase Structural Score to 84.8 (Section G, 1f Structural Score plus PRIORITY retrofit points). This will result in an improved Structural Grade of C (from Table 5, using improved Structural Score).

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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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Example Summary

- Started with a “D”
  - **Poor performer**, DR: 20 to 100%
  - Un-braced cripple walls
  - No foundation anchor bolts
- After retrofits, moved up to a C or B
  - **Fair** to **Good** performer
  - 10 to 60%, to 0 to 50%

Final Comments

- Procedures can be applied across all high seismic hazard zones in the U.S.
- Utilizes a broad set of seismic hazard data, including online maps
- Seismic performance grades are tied to expected loss ratios, albeit broad
- Ample examples in both assessment and retrofit manuals

Thank you …