Appendix A

Maps Showing Seismicity Regions

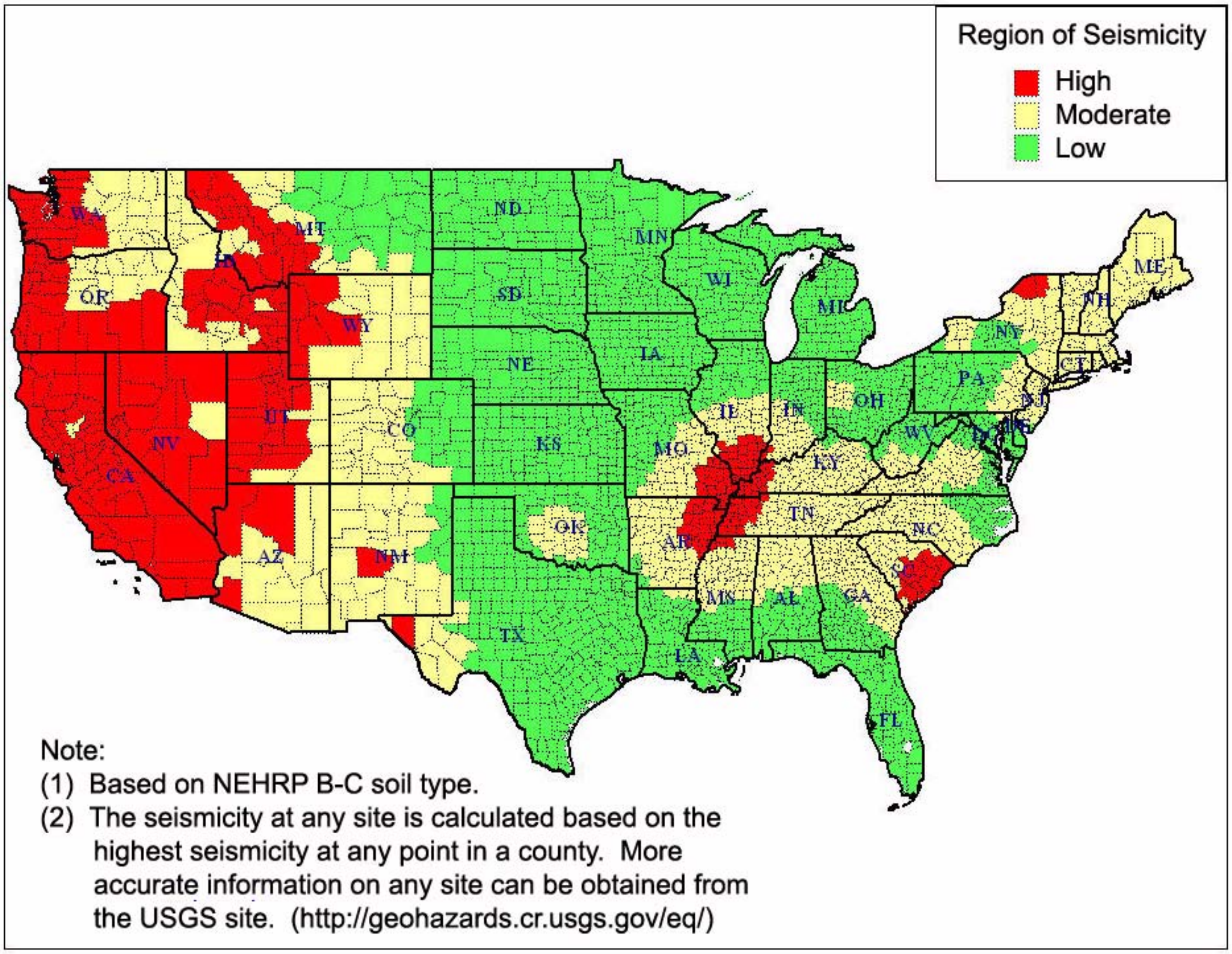


Figure A-1 Seismicity Regions of the Conterminous United States.

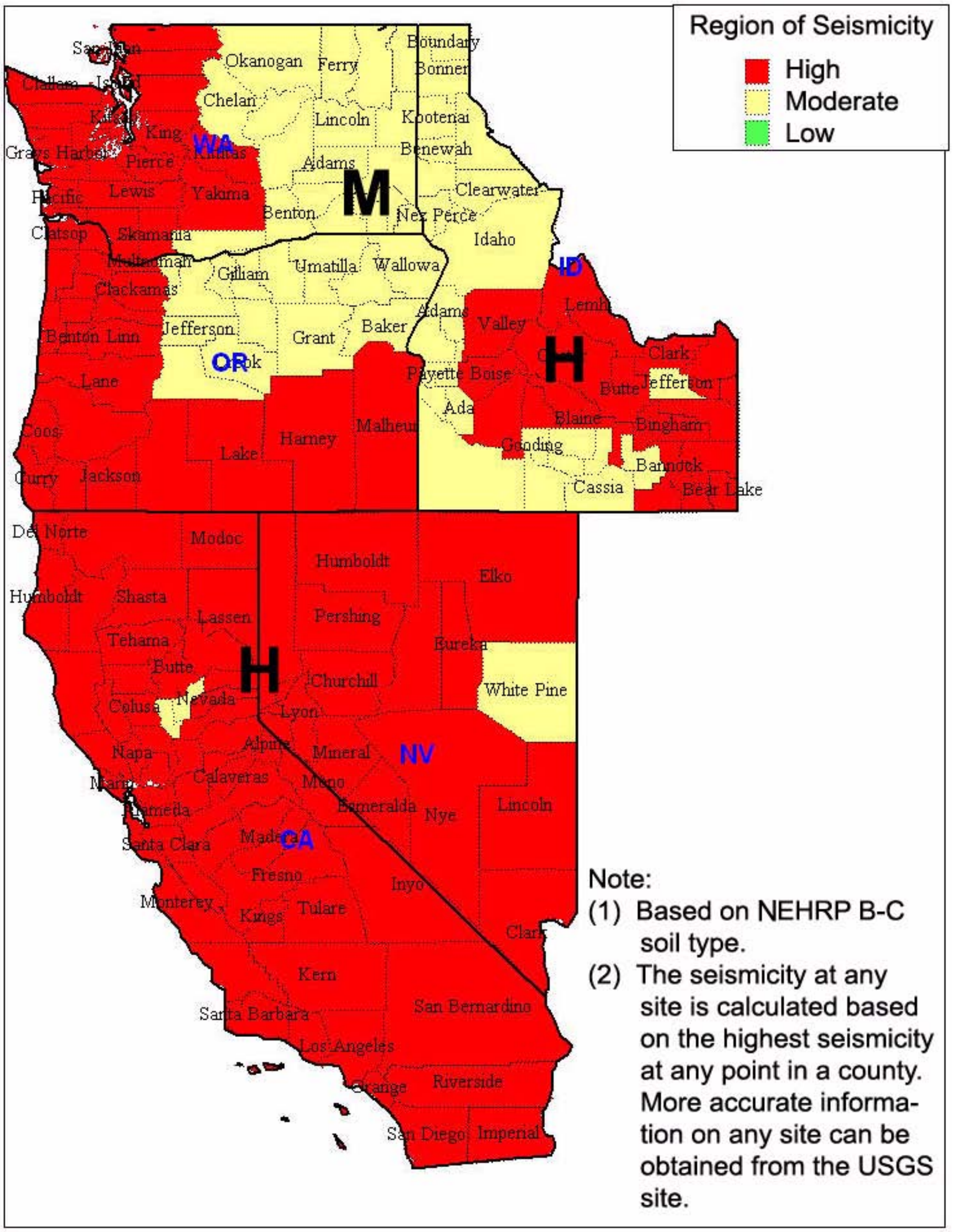


Figure A-2 Seismicity Regions in California, Idaho, Nevada, Oregon, and Washington.

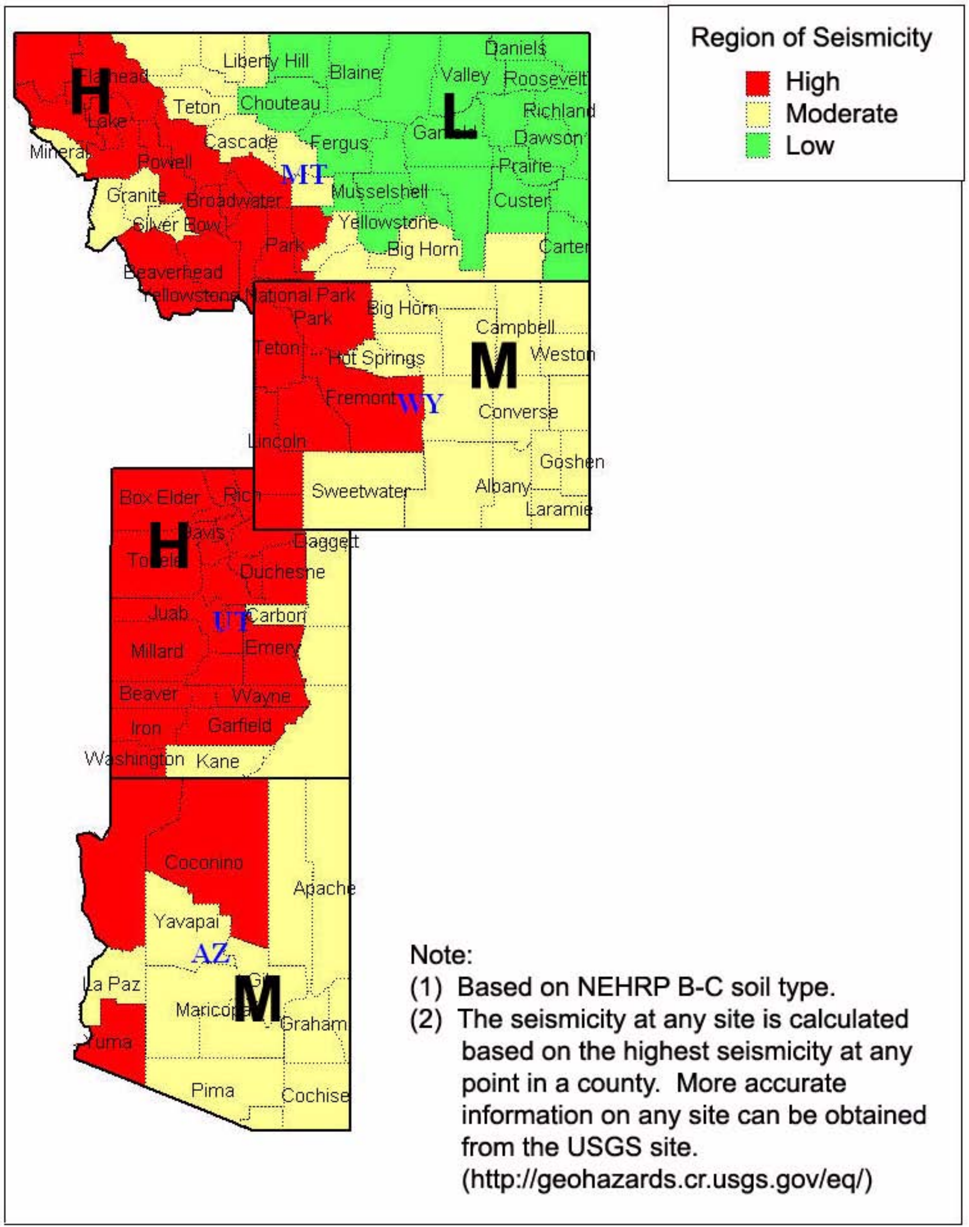


Figure A-3 Seismicity Regions in Arizona, Montana, Utah, and Wyoming.

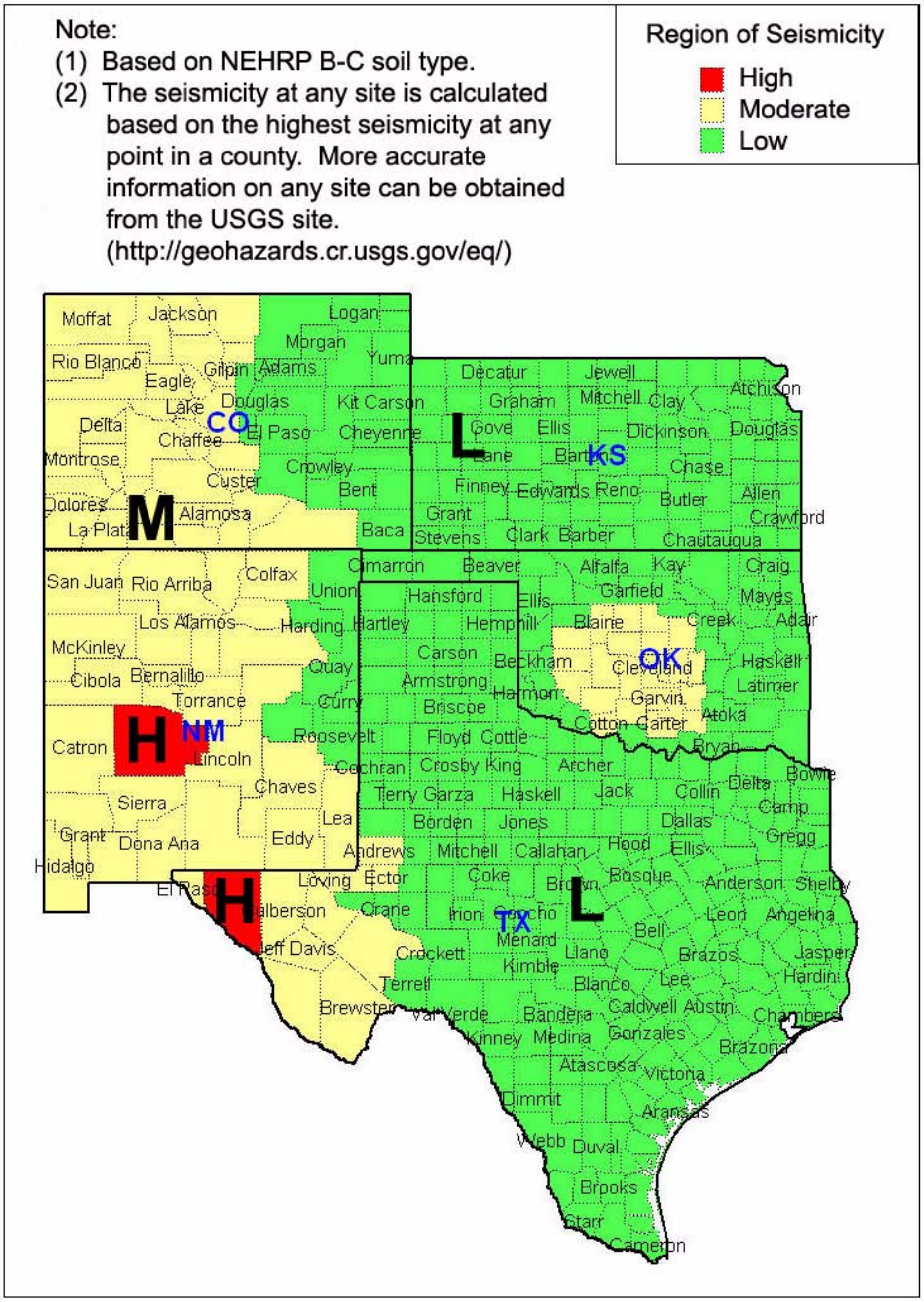


Figure A-4 Seismicity Regions in Colorado, Kansas, New Mexico, Oklahoma, and Texas.

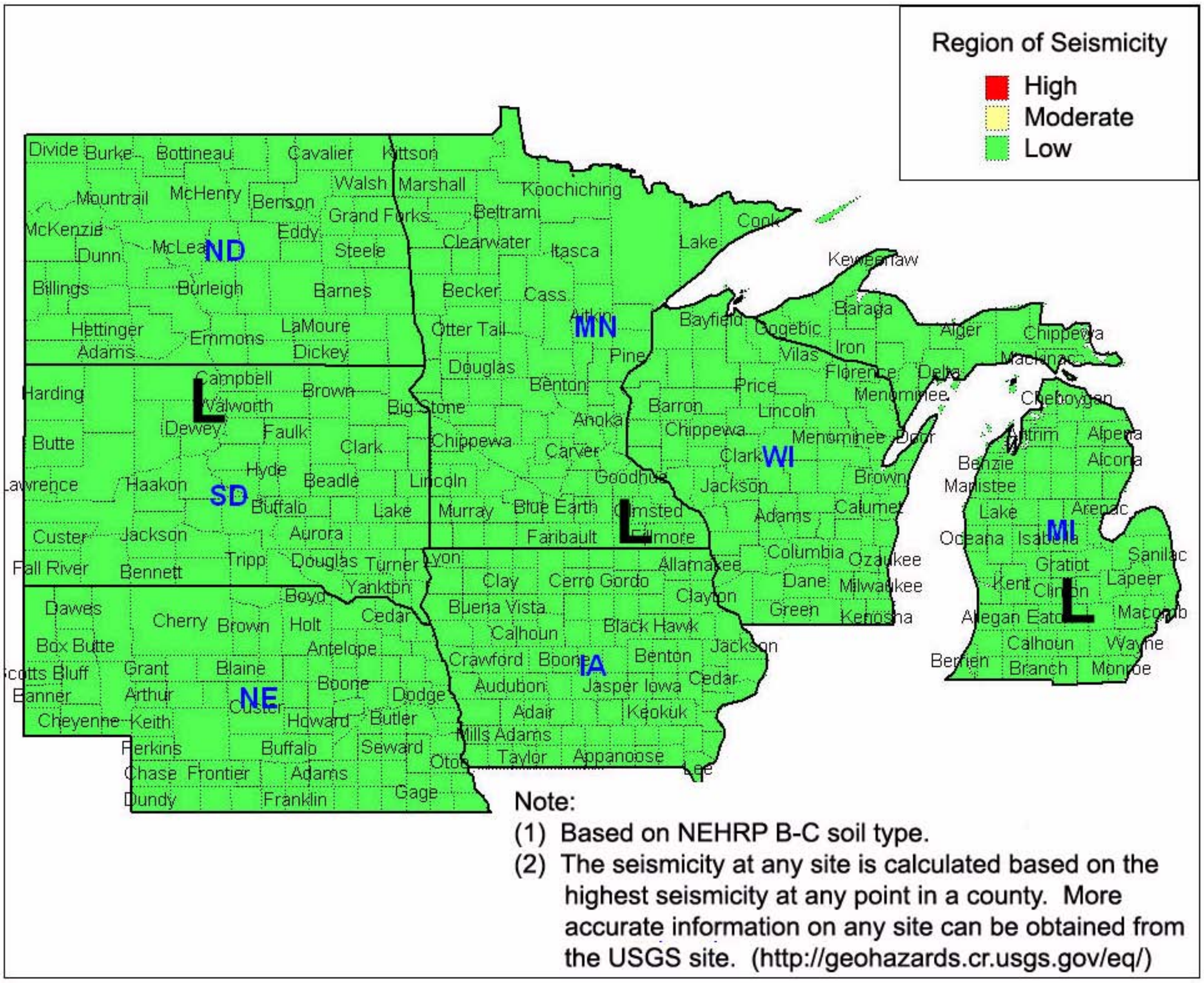


Figure A-5 Seismicity Regions in Iowa, Michigan, Minnesota, Nebraska, North Dakota, South Dakota, and Wisconsin.

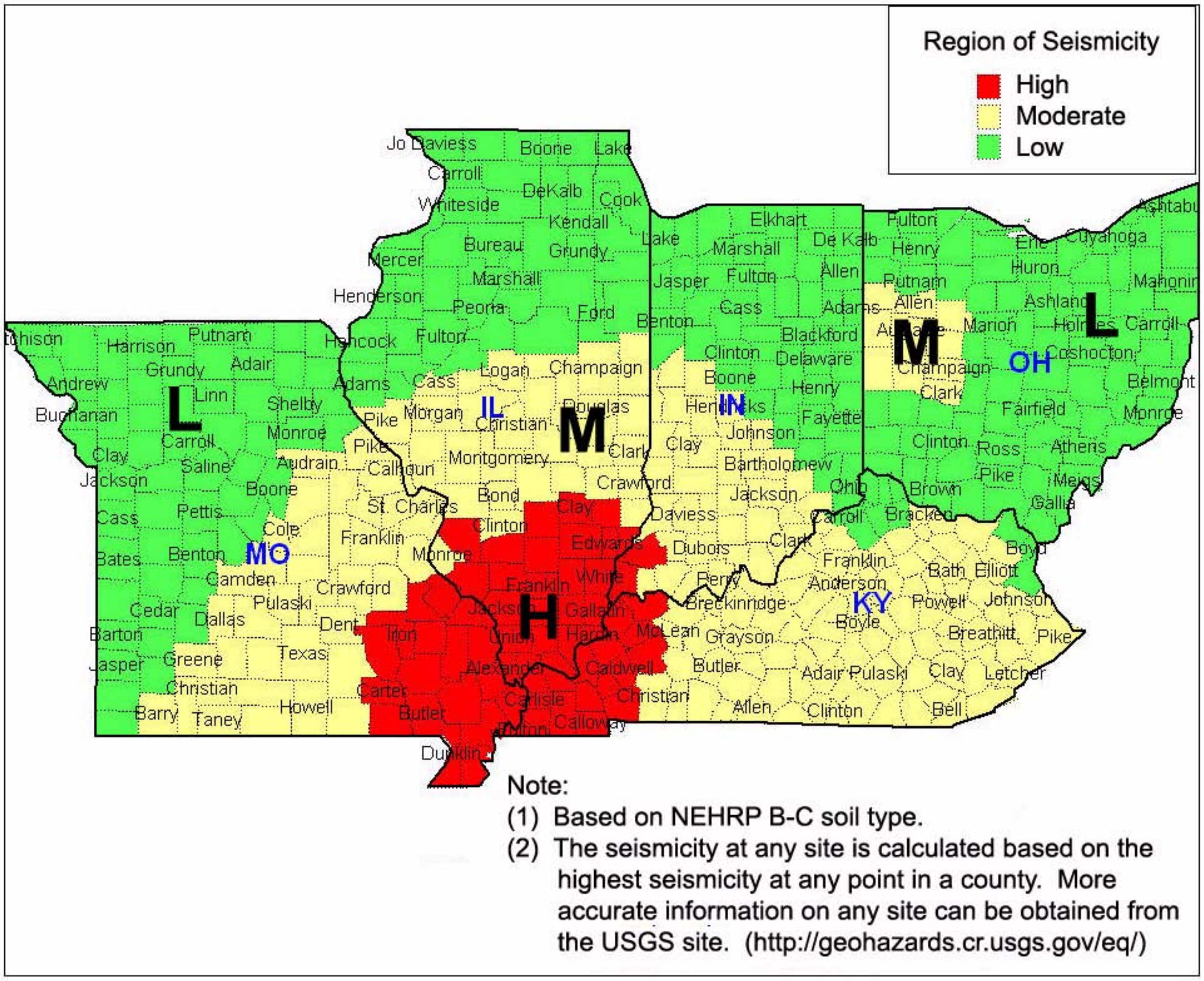


Figure A-6 Seismicity Regions in Illinois, Indiana, Kentucky, Missouri, and Ohio.

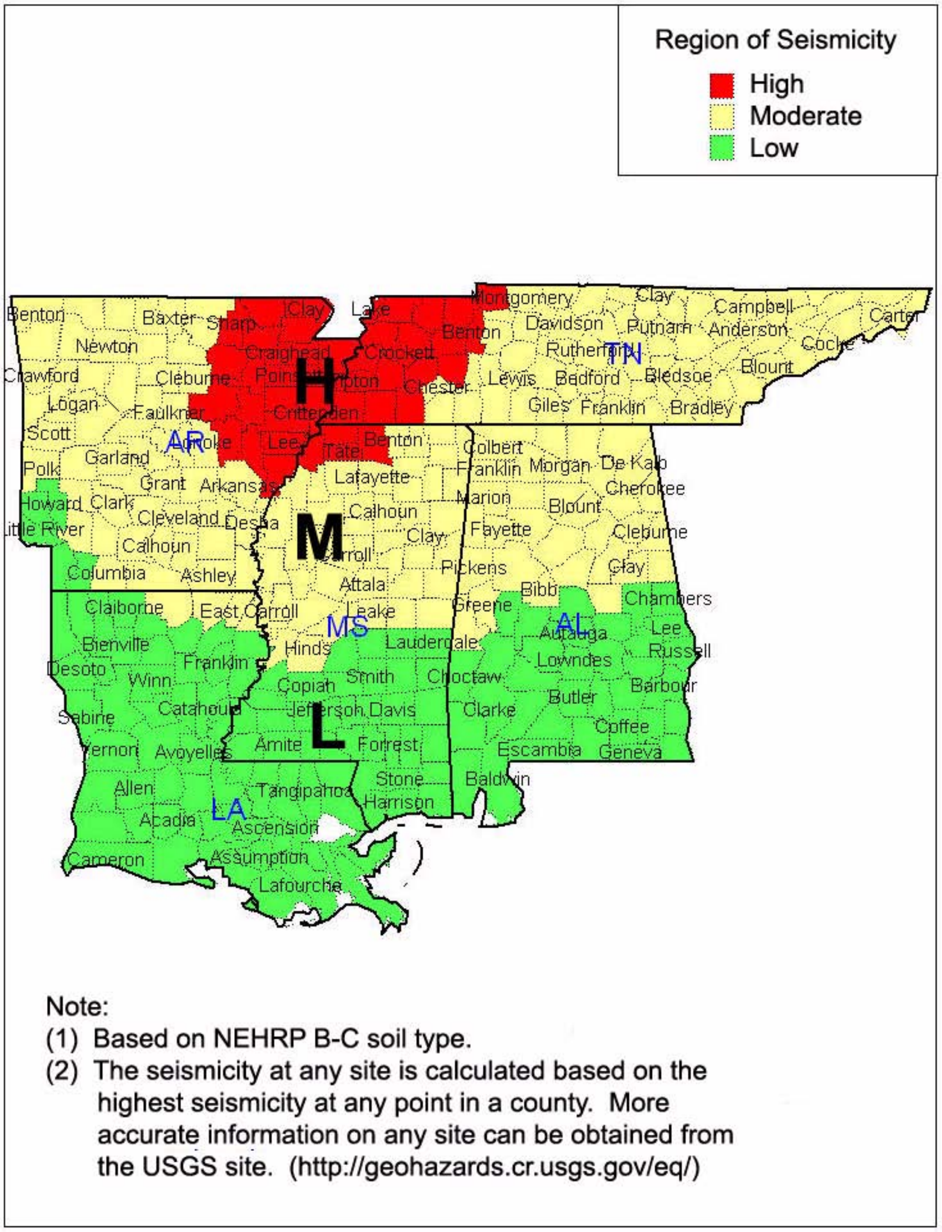


Figure A-7 Seismicity Regions in Alabama, Arkansas, Louisiana, Mississippi, and Tennessee.

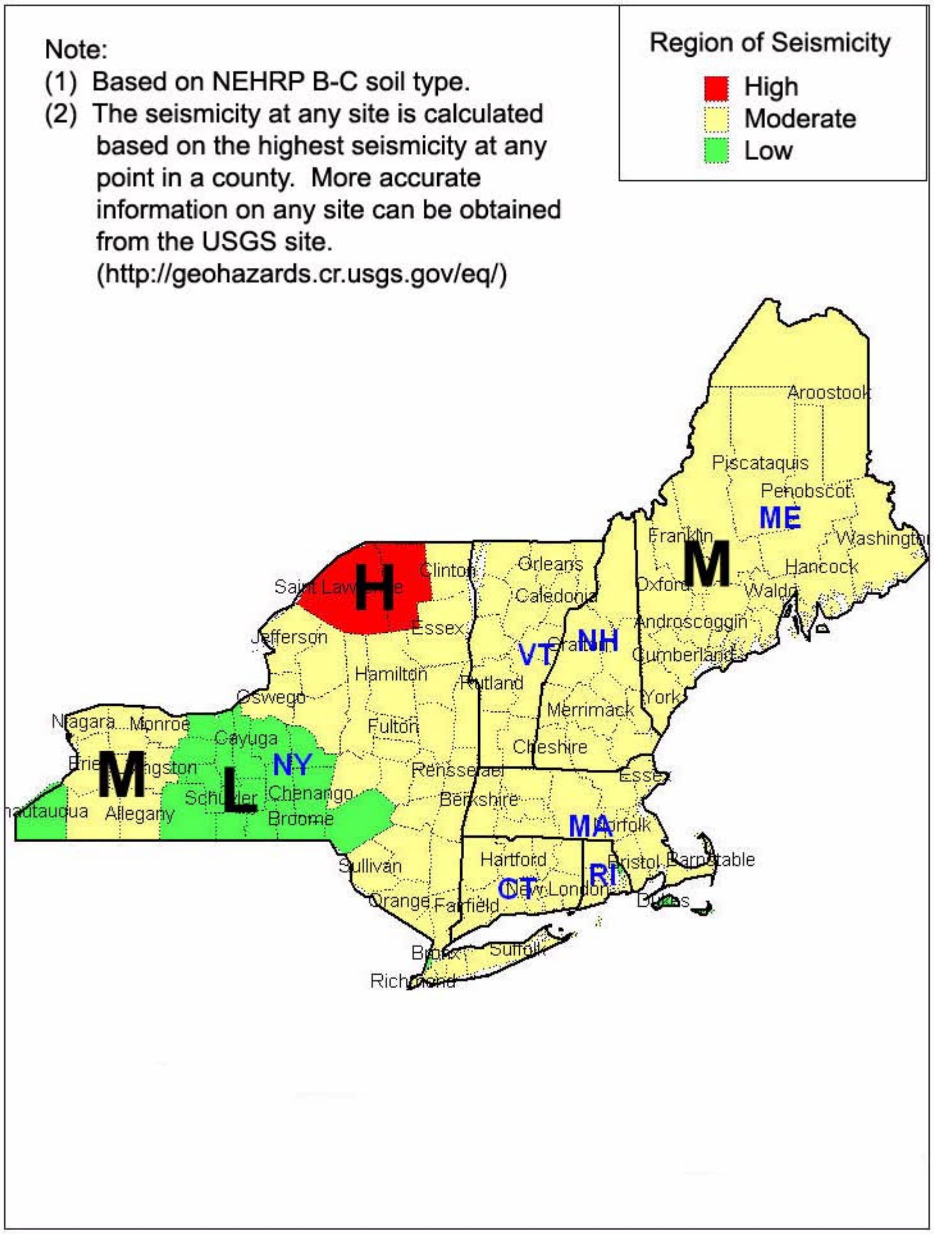


Figure A-8 Seismicity Regions in Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont.

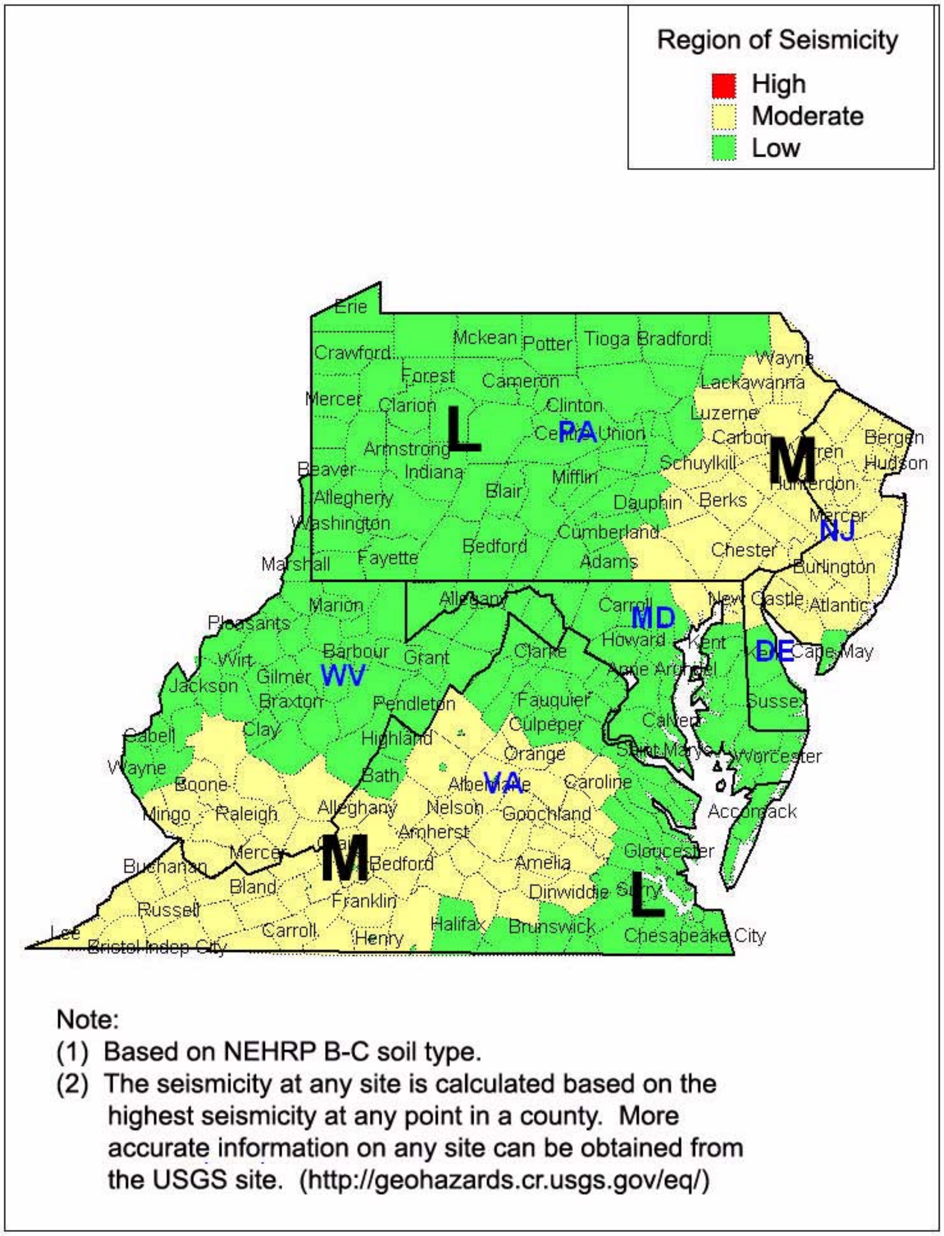


Figure A-9 Seismicity Regions in Delaware, Maryland, New Jersey, Pennsylvania, Virginia, and West Virginia.

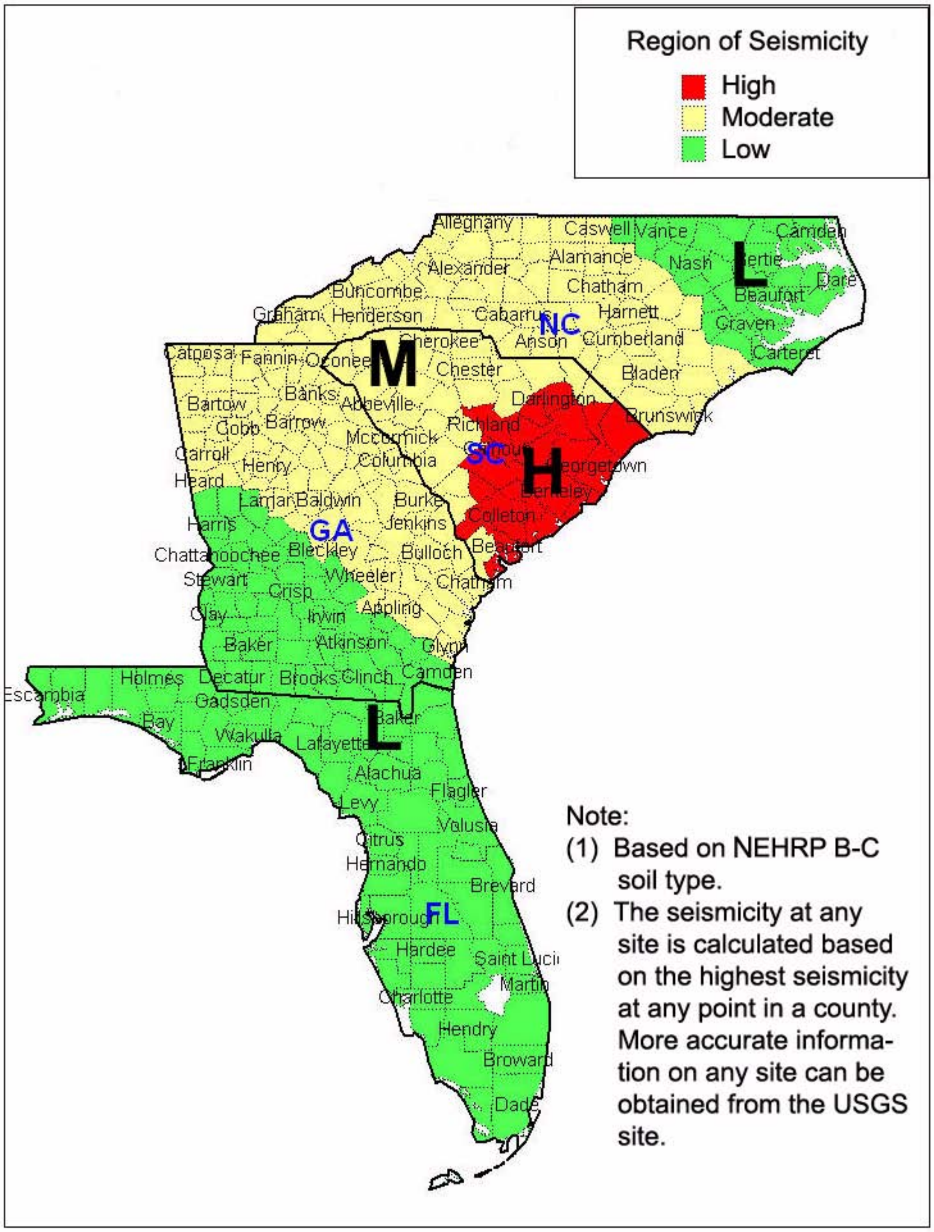


Figure A-10 Seismicity Regions in Florida, Georgia, North Carolina, and South Carolina.

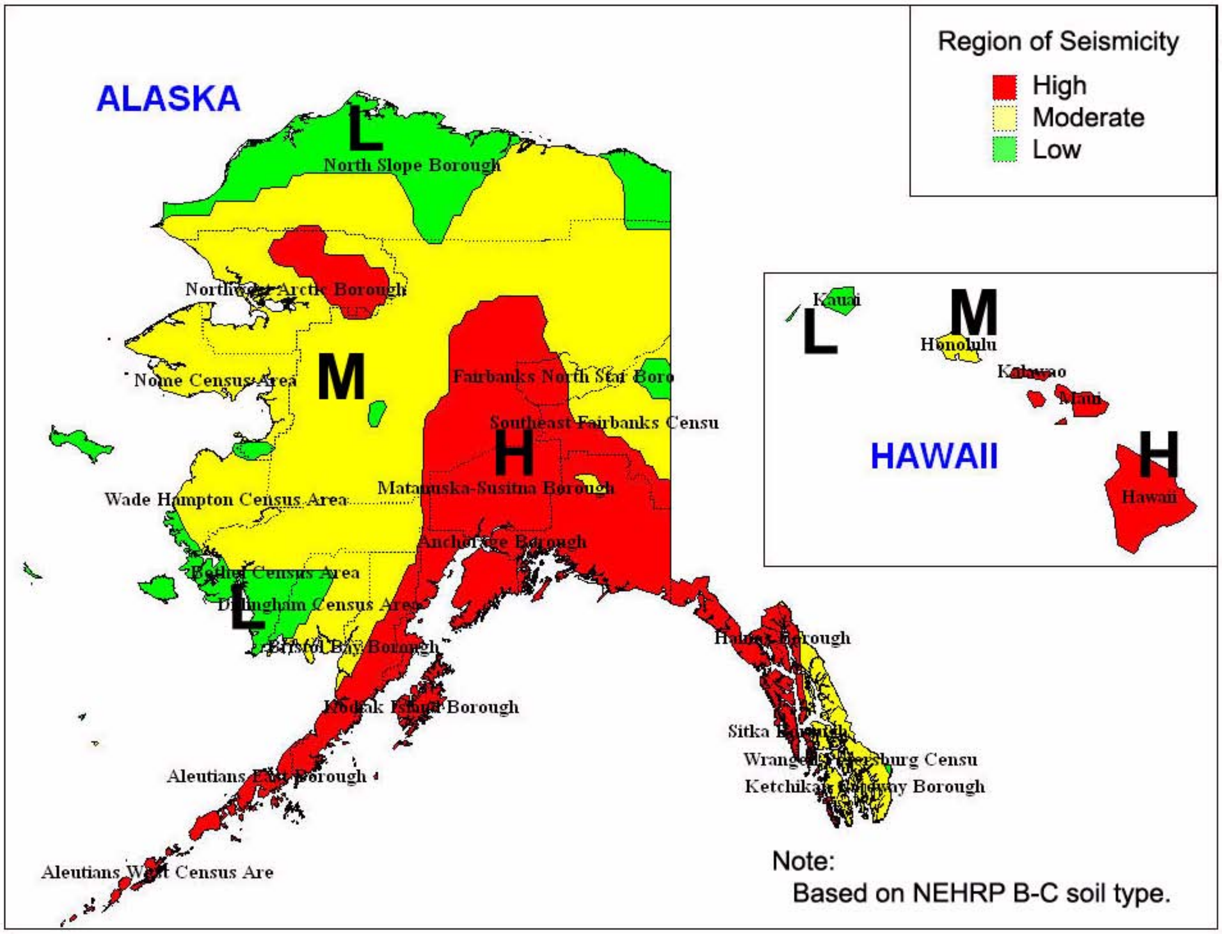


Figure A-11 Seismicity Regions in Alaska and Hawaii.

Appendix B

Data Collection Forms and Quick Reference Guide

Rapid Visual Screening of Buildings for Potential Seismic Hazards

FEMA-154 Data Collection Form

LOW Seismicity

Address: ______________________________

______________________________ Zip ______________

Other Identifiers ______________________________

No. Stories ______________________ Year Built ________

Screener ______________________ Date ______________

Total Floor Area (sq. ft.) ______________________________

Building Name ______________________________

Use ______________________________

Scale:

PHOTOGRAPH

OCCUPANCY			SOIL	TYPE	FALLING HAZARDS
Assembly Commercial Emer. Services	Govt Historic Industrial	Office Residential School	Number of Persons 0 – 10 11 – 100 101-1000 1000+	A Hard Rock B Avg. Rock C Dense Soil D Stiff Soil E Soft Soil F Poor Soil	☐ Unreinforced Chimneys ☐ Parapets ☐ Cladding ☐ Other: ________

BASIC SCORE, MODIFIERS, AND FINAL SCORE, *S*

BUILDING TYPE	W1	W2	S1 (MRF)	S2 (BR)	S3 (LM)	S4 (RC SW)	S5 (URM INF)	C1 (MRF)	C2 (SW)	C3 (URM INF)	PC1 (TU)	PC2	RM1 (FD)	RM2 (RD)	URM
Basic Score	7.4	6.0	4.6	4.8	4.6	4.8	5.0	4.4	4.8	4.4	4.4	4.6	4.8	4.6	4.6
Mid Rise (4 to 7 stories)	N/A	N/A	+0.2	+0.4	N/A	+0.2	-0.2	+0.4	-0.2	-0.4	N/A	-0.2	-0.4	-0.2	-0.6
High Rise (>7 stories)	N/A	N/A	+1.0	+1.0	N/A	+1.0	+1.2	+1.0	0.0	-0.4	N/A	-0.2	N/A	0.0	N/A
Vertical Irregularity	-4.0	-3.0	-2.0	-2.0	N/A	-2.0	-2.0	-1.5	-2.0	-2.0	N/A	-1.5	-2.0	-1.5	-1.5
Plan Irregularity	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8
Pre-Code	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Post-Benchmark	0.0	+0.2	+0.4	+0.6	N/A	+0.6	N/A	+0.6	+0.4	N/A	+0.2	N/A	+0.2	+0.4	+0.4
Soil Type C	-0.4	-0.4	-0.8	-0.4	-0.4	-0.4	-0.4	-0.6	-0.4	-0.4	-0.4	-0.2	-0.4	-0.2	-0.4
Soil Type D	-1.0	-0.8	-1.4	-1.2	-1.0	-1.4	-0.8	-1.4	-0.8	-0.8	-0.8	-1.0	-0.8	-0.8	-0.8
Soil Type E	-1.8	-2.0	-2.0	-2.0	-2.0	-2.2	-2.0	-2.0	-2.0	-2.0	-1.8	-2.0	-1.4	-1.6	-1.4

FINAL SCORE, *S*

COMMENTS

Detailed Evaluation Required

YES NO

* = Estimated, subjective, or unreliable data
DNK = Do Not Know

BR = Braced frame
FD = Flexible diaphragm
LM = Light metal

MRF = Moment-resisting frame
RC = Reinforced concrete
RD = Rigid diaphragm

SW = Shear wall
TU = Tilt up
URM INF = Unreinforced masonry infill

Rapid Visual Screening of Buildings for Potential Seismic Hazards

FEMA-154 Data Collection Form

MODERATE Seismicity

Scale:

Address: ______________________________

______________________________ Zip ______________

Other Identifiers ______________________________

No. Stories ______________________ Year Built ________

Screener ______________________ Date ______________

Total Floor Area (sq. ft.) ______________________

Building Name ______________________________

Use ______________________________

PHOTOGRAPH

OCCUPANCY			SOIL		TYPE						FALLING HAZARDS			
Assembly	Govt	Office	Number of Persons		A Hard Rock	B Avg. Rock	C Dense Soil	D Stiff Soil	E Soft Soil	F Poor Soil	☐ Unreinforced Chimneys	☐ Parapets	☐ Cladding	☐ Other: ______
Commercial	Historic	Residential	0 – 10	11 – 100										
Emer. Services	Industrial	School	101-1000	1000+										

BASIC SCORE, MODIFIERS, AND FINAL SCORE, *S*

BUILDING TYPE	W1	W2	S1 (MRF)	S2 (BR)	S3 (LM)	S4 (RC SW)	S5 (URM INF)	C1 (MRF)	C2 (SW)	C3 (URM INF)	PC1 (TU)	PC2	RM1 (FD)	RM2 (RD)	URM
Basic Score	**5.2**	**4.8**	**3.6**	**3.6**	**3.8**	**3.6**	**3.6**	**3.0**	**3.6**	**3.2**	**3.2**	**3.2**	**3.6**	**3.4**	**3.4**
Mid Rise (4 to 7 stories)	N/A	N/A	+0.4	+0.4	N/A	+0.4	+0.4	+0.2	+0.4	+0.2	N/A	+0.4	+0.4	+0.4	-0.4
High Rise (>7 stories)	N/A	N/A	+1.4	+1.4	N/A	+1.4	+0.8	+0.5	+0.8	+0.4	N/A	+0.6	N/A	+0.6	N/A
Vertical Irregularity	-3.5	-3.0	-2.0	-2.0	N/A	-2.0	-2.0	-2.0	-2.0	-2.0	N/A	-1.5	-2.0	-1.5	-1.5
Plan Irregularity	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
Pre-Code	0.0	-0.2	-0.4	-0.4	-0.4	-0.4	-0.2	-1.0	-0.4	-1.0	-0.2	-0.4	-0.4	-0.4	-0.4
Post-Benchmark	+1.6	+1.6	+1.4	+1.4	N/A	+1.2	N/A	+1.2	+1.6	N/A	+1.8	N/A	2.0	+1.8	N/A
Soil Type C	-0.2	-0.8	-0.6	-0.8	-0.6	-0.8	-0.8	-0.6	-0.8	-0.6	-0.6	-0.6	-0.8	-0.6	-0.4
Soil Type D	-0.6	-1.2	-1.0	-1.2	-1.0	-1.2	-1.2	-1.0	-1.2	-1.0	-1.0	-1.2	-1.2	-1.2	-0.8
Soil Type E	-1.2	-1.8	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6

FINAL SCORE *S*

COMMENTS

Detailed Evaluation Required

YES NO

* = Estimated, subjective, or unreliable data
DNK = Do Not Know

BR = Braced frame
FD = Flexible diaphragm
LM = Light metal

MRF = Moment-resisting frame
RC = Reinforced concrete
RD = Rigid diaphragm

SW = Shear wall
TU = Tilt up
URM INF = Unreinforced masonry infill

Rapid Visual Screening of Buildings for Potential Seismic Hazards

FEMA-154 Data Collection Form

HIGH Seismicity

Scale:

Address: ______________________________

______________________ **Zip** __________

Other Identifiers ______________________

No. Stories ____________ **Year Built** ________

Screener ____________ **Date** ________

Total Floor Area (sq. ft.) ______________

Building Name ______________________

Use ______________________________

PHOTOGRAPH

OCCUPANCY			SOIL		TYPE						FALLING HAZARDS			
Assembly	Govt	Office	Number of Persons		A Hard Rock	B Avg. Rock	C Dense Soil	D Stiff Soil	E Soft Soil	F Poor Soil	☐ Unreinforced Chimneys	☐ Parapets	☐ Cladding	☐ Other: ________
Commercial	Historic	Residential	0 – 10	11 – 100										
Emer. Services	Industrial	School	101-1000	1000+										

BASIC SCORE, MODIFIERS, AND FINAL SCORE, *S*

BUILDING TYPE	W1	W2	S1 (MRF)	S2 (BR)	S3 (LM)	S4 (RC SW)	S5 (URM INF)	C1 (MRF)	C2 (SW)	C3 (URM INF)	PC1 (TU)	PC2	RM1 (FD)	RM2 (RD)	URM
Basic Score	**4.4**	**3.8**	**2.8**	**3.0**	**3.2**	**2.8**	**2.0**	**2.5**	**2.8**	**1.6**	**2.6**	**2.4**	**2.8**	**2.8**	**1.8**
Mid Rise (4 to 7 stories)	N/A	N/A	+0.2	+0.4	N/A	+0.4	+0.4	+0.4	+0.4	+0.2	N/A	+0.2	+0.4	+0.4	0.0
High Rise (> 7 stories)	N/A	N/A	+0.6	+0.8	N/A	+0.8	+0.8	+0.6	+0.8	+0.3	N/A	+0.4	N/A	+0.6	N/A
Vertical Irregularity	-2.5	-2.0	-1.0	-1.5	N/A	-1.0	-1.0	-1.5	-1.0	-1.0	N/A	-1.0	-1.0	-1.0	-1.0
Plan irregularity	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
Pre-Code	0.0	-1.0	-1.0	-0.8	-0.6	-0.8	-0.2	-1.2	-1.0	-0.2	-0.8	-0.8	-1.0	-0.8	-0.2
Post-Benchmark	+2.4	+2.4	+1.4	+1.4	N/A	+1.6	N/A	+1.4	+2.4	N/A	+2.4	N/A	+2.8	+2.6	N/A
Soil Type C	0.0	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
Soil Type D	0.0	-0.8	-0.6	-0.6	-0.6	-0.6	-0.4	-0.6	-0.6	-0.4	-0.6	-0.6	-0.6	-0.6	-0.6
Soil Type E	0.0	-0.8	-1.2	-1.2	-1.0	-1.2	-0.8	-1.2	-0.8	-0.8	-0.4	-1.2	-0.4	-0.6	-0.8
FINAL SCORE, *S*															

COMMENTS

Detailed Evaluation Required

YES NO

* = Estimated, subjective, or unreliable data
DNK = Do Not Know

BR = Braced frame
FD = Flexible diaphragm
LM = Light metal

MRF = Moment-resisting frame
RC = Reinforced concrete
RD = Rigid diaphragm

SW = Shear wall
TU = Tilt up
URM INF = Unreinforced masonry infill

Rapid Visual Screening of Buildings for Potential Seismic Hazards (FEMA 154)

Quick Reference Guide (for use with Data Collection Form)

1. Model Building Types and Critical Code Adoption and Enforcement Dates

Structural Types		Year Seismic Codes Initially Adopted and Enforced*	Benchmark Year when Codes Improved
W1	Light wood frame, residential or commercial, ≤ 5000 square feet	_______	_______
W2	Wood frame buildings, > 5000 square feet.	_______	_______
S1	Steel moment-resisting frame	_______	_______
S2	Steel braced frame	_______	_______
S3	Light metal frame	_______	_______
S4	Steel frame with cast-in-place concrete shear walls	_______	_______
S5	Steel frame with unreinforced masonry infill	_______	_______
C1	Concrete moment-resisting frame	_______	_______
C2	Concrete shear wall	_______	_______
C3	Concrete frame with unreinforced masonry infill	_______	_______
PC1	Tilt-up construction	_______	_______
PC2	Precast concrete frame	_______	_______
RM1	Reinforced masonry with flexible floor and roof diaphragms	_______	_______
RM2	Reinforced masonry with rigid diaphragms	_______	_______
URM	Unreinforced masonry bearing-wall buildings	_______	_______

*Not applicable in regions of low seismicity

2. Anchorage of Heavy Cladding

Year in which seismic anchorage requirements were adopted: _______

3. Occupancy Loads

Use	Square Feet, Per Person	Use	Square Feet, Per Person
Assembly	varies, 10 minimum	Industrial	200-500
Commercial	50-200	Office	100-200
Emergency Services	100	Residential	100-300
Government	100-200	School	50-100

4. Score Modifier Definitions

Mid-Rise: 4 to 7 stories

High-Rise: 8 or more stories

Vertical Irregularity: Steps in elevation view; inclined walls; building on hill; soft story (e.g., house over garage); building with short columns; unbraced cripple walls.

Plan Irregularity Buildings with re-entrant corners (L, T, U, E, + or other irregular building plan); buildings with good lateral resistance in one direction but not in the other direction; eccentric stiffness in plan, (e.g. corner building, or wedge-shaped building, with one or two solid walls and all other walls open).

Pre-Code: Building designed and constructed prior to the year in which seismic codes were first adopted and enforced in the jurisdiction; use years specified above in Item 1; default is 1941, except for PC1, which is 1973.

Post-Benchmark: Building designed and constructed after significant improvements in seismic code requirements (e.g., ductile detailing) were adopted and enforced; the benchmark year when codes improved may be different for each building type and jurisdiction; use years specified above in Item 1 (see Table 2-2 of FEMA 154 *Handbook* for additional information).

Soil Type C: Soft rock or very dense soil; S-wave velocity: 1200 – 2500 ft/s; blow count > 50; or undrained shear strength > 2000 psf.

Soil Type D: Stiff soil; S-wave velocity: 600 – 1200 ft/s; blow count: 15 – 50; or undrained shear strength: 1000 – 2000 psf.

Soil Type E: Soft soil; S-wave velocity < 600 ft/s; or more than 100 ft of soil with plasticity index > 20, water content > 40%, and undrained shear strength < 500 psf.

Appendix C

Review of Design and Construction Drawings

Drawing styles vary among engineering offices, but the conventions used are very consistent. The following are some of the common designations:

1. Around the perimeter of the building, the exterior walls will be shown as a double line, if the space between the lines is empty, this will usually be a wood stud wall.
2. Concrete walls will be shaded.
3. Masonry walls will be cross hatched.
4. Horizontal beams and girders will be shown with a solid line for steel and wood, and a double solid or dotted line for concrete.
   - Steel framing will have a notation of shape, depth, and weight of the member. The designations will include W, S, I, B and several others followed by the depth in inches, an "x," and the weight in pounds per lineal foot. An example would be W8x10 (wide flange shape, 8" deep, 10 lbs/ft).
   - Wood framing will have the width and depth of the member. An example would be 4x10 (4" wide and 10" deep). Floor joists and roof rafters will be shown with the same call-out except not all members will be shown. A few at each end of the area being framed will show and there will be an arrow showing the extent and the call-out of the size members.
   - Concrete framing will have the width and depth. Where steel and wood are shown as single line, concrete will be shown as a double line. An example of the call out would be 12x24 (12" wide and 24" deep). Additionally, or in lieu of the number call-out, the member might be given a letter and number (B-1 or G-1) with a reference to a schedule for the size and reinforcing. "B" stands for beam and "G" stands for girder. Usually, beams are smaller than girders and span between girders while girders will be larger and frame between columns.
5. Columns will show on the floor plans as their shape with a shading designation where appropriate:
   - Steel column will be shown as an "H" rotated to the correct orientation for the location on the plan.
   - Wood column will be an open square.
   - Concrete column will be either a square or a circle depending on the column configuration. The square or circle will be shaded.
6. Steel moment frames will show the columns with a heavy line between the columns representing the beam or girder. At each end of the beam or girder at the column will be a small triangle shaded. This indicates that the connection between the beam or girder and the column is fully restrained.

Appendix D

Exterior Screening for Seismic System and Age

D.1 Introduction

A successful evaluation of a building is dependent on the screener's ability to identify accurately the construction materials, lateral-force-resisting system, age, and other attributes that would modify its earthquake performance (e.g., vertical or plan irregularities). This appendix includes discussions of inspection techniques that can be used while viewing from the street.

D.2 What to Look for and How to Find It

It may be difficult to identify positively the structural type from the street as building veneers often mask the structural skeleton. For example, a steel frame and a concrete frame may look similar from the outside. Features typical of a specific type of structure may give clues for successful identification. In some cases there may be more than one type of frame present in the structure. Should this be the case, the predominant frame type should be indicated on the form.

Following are attributes that should be considered when trying to determine a building lateral-force-resisting system from the street:

1. *Age*: The approximate age of a building can indicate the possible structure type, as well as indicating the seismic design code used during the building design process. Age is difficult to determine visually, but an approximation, accurate within perhaps a decade, can be estimated by looking at the architectural style and detail treatment of the building exterior, if the facade has not been renovated. If a building has been renovated, the apparent age is misleading. See Section D.3 for additional guidance.
2. *Facade Pattern*: The type of structure can sometimes be deduced by the openness of the facade, or the size and pattern of window openings. The facade material often can give hints to the structure beneath. Newer facade materials likely indicate that modern construction types were used in the design and may indicate that certain building types can be eliminated.
3. *Height*: The number of stories will indicate the possible type of construction. This is particularly useful for taller buildings, when combined with knowledge of local building practice. See Section D.4 for additional guidance.
4. *Original Use*: The original use can, at times, give hints as to the structural type. The original use can be inferred from the building character, if the building has not been renovated. The present use may be different from the original use. This is especially true in neighborhoods that have changed in character. A typical example of this is where a city's central business district has grown rapidly, and engulfed what were once industrial districts. The buildings' use has changed and they are now either mixed office, commercial or residential (for office workers).

D.3 Identification of Building Age

The ability to identify the age of a building by considering its architectural style and construction materials requires an extensive knowledge of architectural history and past construction practice. It is beyond the scope of this *Handbook* to discuss the various styles and construction practices. Persons involved in or interested in buildings often have a general knowledge of architectural history relevant to their region. Interested readers should refer to in-depth texts for more specific information.

Photographs, architectural character, and age of (1) residential, (2) commercial, and (3) mixed use and miscellaneous buildings, are illustrated in Tables D-1 through D-3, respectively. Photographs of several example steel frame and concrete frame buildings under construction are provided in Figure D-1. The screener should study these photographs and characteristics closely to assist in differentiating architectural styles and facade treatment of various periods. Facade renovation (see photos b and c in Figure D-1) can clearly alter the original appearance. When estimating building age, the screener should look at the building from all sides as facade renovation often occurs only at the building front. A new building will seldom look like an old one. That

Table D-1 Photographs, Architectural Characteristics, and Age of Residential Buildings

<table>
<tr><th>Examples</th><th>Characteristics</th></tr>
<tr><td rowspan="2">

a. 1965-1980

b. 1965-1980

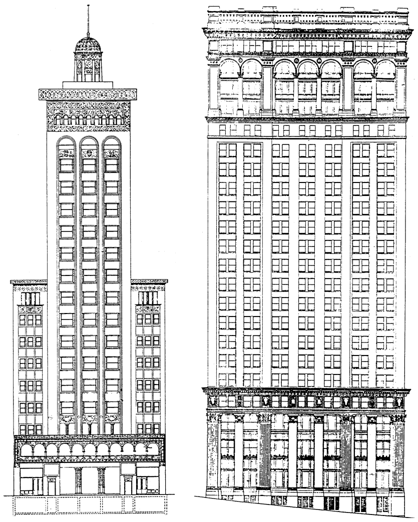
c. 1965-1980

d. 1960-1975 reinforced concrete shear wall

e. Pre-1933 URM (rehabilitated)
</td><td>
<u>Low-Rise Buildings (1-3 stories):</u>
• Typically wood or masonry
• May have ground floor or basement parking, a soft story
• Older buildings typically have more architectural detail, ornamentation
• 1950s and later are more ‘modern’ – lacking ornamentation, typically with more horizontal lines
Common structural types: W2, RM1, RM2, URM
</td></tr>
<tr><td>
<u>Mid-Rise (4-7 stories) and High-Rise Buildings (8 stories and higher):</u>
• Typically, reinforced concrete (older, URM)
• May have commercial ground floor, a soft story
• Older buildings typically have more cornices, architectural detail, ornamentation
• 1950s and later are lacking ornamentation, typically with stronger vertical or horizontal lines
Common structural types: W2, RM1, RM2, URM
</td></tr>
</table>

Table D-2 Illustrations, Architectural Characteristics, and Age of Commercial Structures

Examples



a. Pre-1930

b. 1910-1920
(Steel frame with unreinforced masonry infill that has been seismically rehabilitated)

c. 1920-1930

d. 1920-1930

e. 1890-1900

Characteristics

<u>Pre-1950</u>

- Building has flat roof with cornices, or several set-backs.
- Ornate decorative work in concrete, terra cotta, cast stone or iron.
- Large bell tower or clock tower is common.
- Simple pattern of windows on all sides.
- Floors are concrete slabs on steel or concrete beams.
- Exterior is stone, terra cotta or concrete.

Common Structure Types:
S2, S5, C2, C3

Table D-2 **Illustrations, Architectural Characteristics, and Age of Commercial Structures (Continued)**

<table>
<tr><th>Examples</th><th>Characteristics</th></tr>
<tr><td>

f. 44 story, 1960s, L-shape on the left; 20 story, 1914, with setback on the right

g. 1950-1975

i. 1950-1975

h. 1940-1950

j. 1950-1975
</td><td>
<u>1950-1975</u>

Flat roof, typically with no cornice.
Building is square or rectangular full height, fewer setbacks.
First story and top story can be taller than other stories. In some cases the top story could be shorter than others.
Exterior finishes metal or glass, pre-cast stone or concrete.
Floors are concrete slab over steel or concrete beams.

Common Structure Types: S1, S2, S4, C1, C2
</td></tr>
</table>

Table D-2 Illustrations, Architectural Characteristics, and Age of Commercial Structures (Continued)

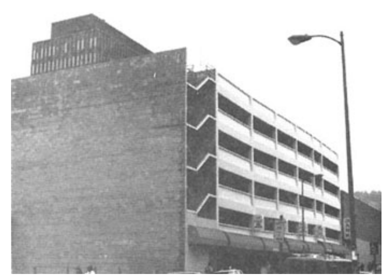
Examples	*Characteristics*
 k. Post-1975  l. Post-1975  m. Post-1975  n. Post-1975  o. Post-1975	**Post-1975** ● Flat roof, typically with no cornice. ● Building is square or rectangular for its full height, fewer setbacks. ● First story and top story can be taller than other stories. (In some cases, though, the top story could be shorter than others.) ● Exterior finishes: metal or glass, pre-cast stone or concrete, with little ornamentation ● Floors are concrete slabs over steel or concrete beams. Common Structure Types: S1, S2, S4, C1, C2

is, a building is usually at least as old as it looks. Even when designed to look old, telltale signs of modern techniques can usually be seen in the type of windows, fixtures, and material used.

D.4 Identification of Structural Type

The most common inspection that will be utilized with the RVS procedure will be the exterior or "sidewalk" or "streetside" survey. First, the evaluation should be as thorough as possible and performed in a logical manner. The street-facing front of the building is the starting point and the evaluation begins at the ground and progressively moves up the exterior wall to the roof or parapet line. For taller buildings, a pair of binoculars is useful. When a thorough inspection of the street-front elevation has been completed, the procedure is repeated on the next accessible wall. From the exterior, the screener should be able to determine the approximate age of the building, its original occupancy, and count the number of stories.

Table D-3 Photographs, Architectural Characteristics, and Age of Miscellaneous Structures

Examples	*Characteristics*
 a. 1920-1930  b. 1920-1950  c. 1990-2000  d. 1990-2000; airport terminal  e. 1920-1930; windows create coupled shear walls.  f. Pre-1930  g. 1950 – 1965 parking structure  h. 1920-1930; theater and shops complex, reinforced concrete	Mixed use (residential with a commercial first floor), places of assembly, theatres, triangular buildings, halls, parking structures: • Long spans • Tall first story (for commercial use) – soft or weak story • Atria or irregular floor-to-floor layout

a. Building above is a high-rise steel dual system – moment frame (heavy columns and beams on upper facade) with bracing around elevator core. Fireproofing is being applied to steel at mid-height (inside the shroud) and precast facade elements are being attached to frame in lower stories.

b. Reinforced concrete frame under renovation – demolition of older facade units.

c. New precast facade units being applied to reinforced concrete frame buildings.

Figure D-1 Photos showing basic construction, in steel-frame buildings and reinforced concrete-frame buildings.

With this information, Tables D-4 through D-7 provide the most likely structural system type, based on original occupancy and number of stories. (These tables are based on expert judgment and would benefit from verification by design professionals and building regulatory personnel familiar with local design and construction practices.)

In addition to using information on occupancy and number of stories, as provided in Tables D-4 through D-7, the following are some locations that

Table D-4 Most Likely Structural Types for Pre-1930 Buildings

Original Occupancy	*Number of Stories* 1-2	3	4-6	7-15	15-30	30+
Residential	W URM	W URM	S5 C3 URM	S5 C3		
Commercial	W S4 S5 C1 C2 C3 URM	W S4 S5 C1 C2 C3 URM	S1 S2 S4 S5 C1 C2 C3 URM	S1 S2 S4 S5 C1 C2 C3	S1 S2 S4 S5 C1 C2 C3	
Industrial	W S1 S2 S3 S5 C1 C2 C3 URM	W S1 S2 S5 C1 C2 C3 URM				

Note: If it is not possible to identify immediately the structural type for a pre-1930 building, the original occupancy and number of stories will provide some guidance. The building will need further inspection for precise identification.

Table D-5 Most Likely Structural Types for 1930-1945 Buildings

Original Occupancy	*Number of Stories* 1-2	3	4-6	7-15	15-30	30+
Residential	W URM	W URM	S1 S2 S5 URM	S1 S2 S5		
Commercial	W S1 S2 S5 C1 C2 C3 RM1 RM2 URM	W S1 S2 S5 C1 C2 C3 RM1 RM2 URM	S1 S2 S5 C1 C2 C3 RM1 RM2 URM	S1 S2 S5 C1 C2 C3	S1 S2 S5 C1 C2 C3	S2 S5
Industrial	S3 S5 C1 C2 C3 RM1 RM2 URM	S3 S5 C1 C2 C3 RM1 RM2 URM	C1 C2 C3			

Note: If it is not possible to identify immediately the structural type for a 1930-1945 building, the original occupancy and number of stories will provide some guidance. The building will need further inspection for precise identification.

Table D-6 Most Likely Structural Types for 1945-1960 Buildings

	Number of Stories					
Original Occupancy	*1-2*	*3*	*4-6*	*7-15*	*15-30*	*30+*
Residential	W RM URM*	W RM URM*	S1 S2 C1 C2 RM1,2 URM*	S1 S2 C1 C2	S1 S2 C1 C2	S1 S2 C1 C2
Commercial	W S1 S2 C1 C2 RM1,2 URM*	W S1 S2 C1 C2 RM1,2 URM*	S1 S2 C1 C2 RM1 RM2 URM*	S1 S2 C1 C2	S1 S2 C1 C2	S1 S2 C1 C2
Industrial	C1 C2 PC1 RM1 RM2 URM*	S1 S2 C1 C2 RM1,2 URM*	S1 S2 C1 C2 RM1,2 URM*			

Notes: If it is not possible to identify immediately the structural type for a 1945-1960 building, the original occupancy and number of stories will provide some guidance. The building will need further inspection for precise identification.

*By this period, URM was generally not permitted in California or other high-seismicity locations, so that only in the central or eastern U.S. would buildings of this age be URM.

Table D-7 Most Likely Structural Types for Post-1960 Buildings

	Number of Stories					
Original Occupancy	*1-2*	*3*	*4-6*	*7-15*	*15-30*	*30+*
Residential	W S1 S2 C1 C2 PC2 RM1,2	W S1 S2 C1 C2 PC2 RM1,2	W S1 S2 C1 C2 PC2 RM1,2	S1 S2 C1 C2 PC2 RM1 RM2		
Commercial	W S1 S2 C1 C2 PC1 PC2 RM1,2	W S1 S2 C1 C2 PC1 PC2 RM1,2	W S1 S2 C1 C2 PC2 RM1 RM2	S1 S2 C1 C2 PC2 RM1 RM2	S1 S2 C1 C2 PC2	S1 S2 C1 C2
Industrial	S1 S2 S3 C1 C2 PC1 PC2 RM1,2	S1 S2 C1 C2 PC1 PC2 RM1 RM2	S1 S2 C1 C2 PC2 RM1 RM2	S1 S2 C1 C2 PC2	C1 C2 PC2	

Note: If it is not possible to identify immediately the structural type for a post-1960 building, the original occupancy and number of stories will provide some guidance. The building will need further inspection for precise identification.

the screener can look, without performing destructive investigations, to gain insight into the structure type:

1. In newer frame construction the columns are often exposed on the exterior in the first story. If the columns are covered with a facade material, they are most likely steel columns, indicating a steel frame. If the frames are concrete, they are usually exposed and not covered with a facade. See Figures D-2 and D-3.
2. Some structures use a combination of shear walls in the transverse direction and frames in the longitudinal direction. This can be seen from the exterior as the shear walls usually extend through the exterior longitudinal wall and are exposed there. This is most common in hotels and other residential structures where balconies are included. See Figure D-4.
3. An inspection of doorways and window framing can determine wall thickness. When the thickness exceeds approximately 12 inches, the wall is most likely unreinforced masonry (URM).

Figure D-2 Building with exterior columns covered with a facade material.

4. If there are vertical joints in the wall, regularly spaced and extending to the full height, the wall is constructed of concrete, and if three or less stories in height, the structure type is most likely a tilt-up (PC1). See Figure D-5.
5. If the building is constructed of brick masonry without header courses (horizontal rows of visible brick ends), and the wall thickness is approximately 8 inches, the structural type is most likely reinforced masonry (RM1 or RM2). See Figure D-6.

Figure D-3 Detail of the column facade of Figure D-2.

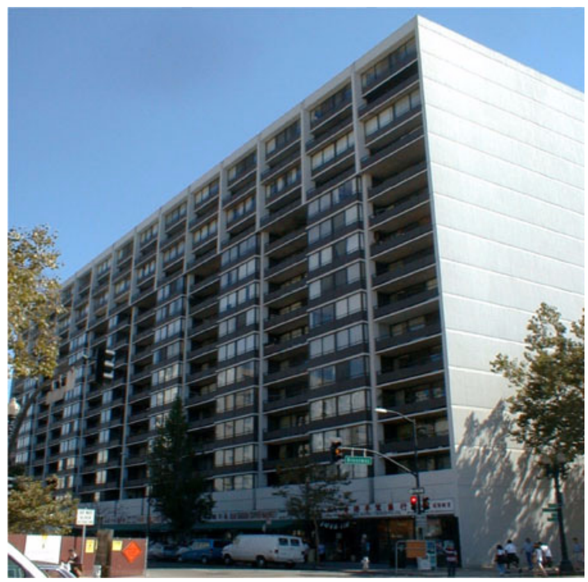


Figure D-4 Building with both shear walls (in the short direction) and frames (in the long direction).

6. If the exterior wall shows large concrete block units (approximately 8 to 12 inches high and 12 to 16 inches in length), either smooth or rough faced, the structure type may be reinforced concrete block masonry. See Figure D-7.

Because many buildings have been renovated, the screener should know where to look for clues to the original construction. Most renovations are done for commercial retail spaces, as businesses like to have an up-to-date image. Most exterior renovations are only to the front of the building or to walls that attract attention. Therefore, the original construction

Figure D-5 Regular, full-height joints in a building's wall indicate a concrete tilt-up.

Figure D-6 Reinforced masonry wall showing no course of header bricks (a row of visible brick ends).

can often be seen at the sides, or the rear, where people generally do not look. If the original material is covered in these areas, it is often just painted or lightly plastered. In this case, the pattern of the older material can often still be seen.

Clues helping identify the original material are apparent if one is looking for them. Two examples are included here:

- Figure D-8 shows a building with a 1970s polished stone and glass facade. The side of the building indicates that it is a pre-1930 URM bearing-wall structure.
- Figure D-9 shows a building facade with typical 1960s material. The side was painted. Showing through the paint, the horizontal board patterns in the poured-in-place concrete wall of pre-1940 construction could still be seen.

Figure D-7 Reinforced masonry building with exterior wall of concrete masonry units, or concrete blocks.

Figure D-8 A 1970s renovated facade hides a URM bearing-wall structure.

D.5 Characteristics of Exposed Construction Materials

Accurate identification of the structural type often depends on the ability to recognize the exposed construction material. The screener should be familiar

Figure D-9 A concrete shear-wall structure with a 1960s renovated facade.

Figure D-10 URM wall showing header courses (identified by arrows) and two washer plates indicating wall anchors.

with how different materials look on existing buildings as well as how they have been installed. Brief descriptions of some common materials are included here:

- *Unreinforced Masonry*—Unreinforced masonry walls, when they are not veneers, are typically several wythes thick (a wythe is a term denoting the width of one brick). Therefore, header bricks will be apparent in the exposed surface. Headers are bricks laid with the butt end on the exterior face, and function to tie wythes of bricks together. Header courses typically occur every six or seven courses. (See Figures D-10 and D-11.) Sometimes, URM infill walls will not have header bricks, and the wythes of brick are held together only by mortar. Needless to say, URM will look old, and most of the time show wear and weathering. URM may also have a soft sand-lime mortar which may be detected by scratching with a knife, unless the masonry has been repointed.
- *Reinforced Masonry*—Most reinforced brick walls are constructed using the hollow grout method. Two wythes of bricks are laid with a hollow space in between. This space contains the reinforcement steel and is grouted afterward (see Figure D-12). This method of construction usually does not include header bricks in the wall surface.
- *Masonry Veneer*—Masonry veneers can be of several types, including prefabricated panels, thin brick texture tiles, and a single wythe of brick applied onto the structural backing. Figures D-13 shows brick veneer panels. Note the discontinuity of the brick pattern interrupted by the vertica1 gaps. This indicates that the surface is probably a veneer panel. The scupper opening at the top of the wall, probably to let the rainwater on the roof to drain, also indicates that this is a thin veneer rather than a solid masonry

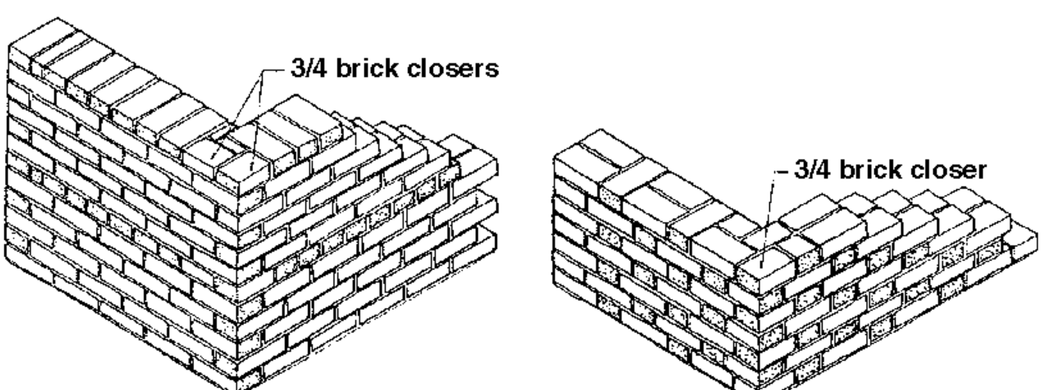


Figure D-11 Drawing of two types of masonry pattern showing header bricks (shown with stipples).

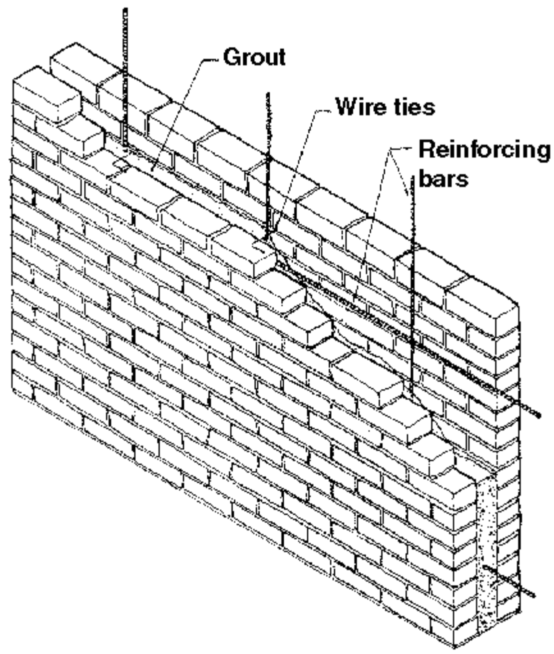


Figure D-12 Diagram of common reinforced masonry construction. Bricks are left out of the bottom course at intervals to create cleanout holes, then inserted before grouting.

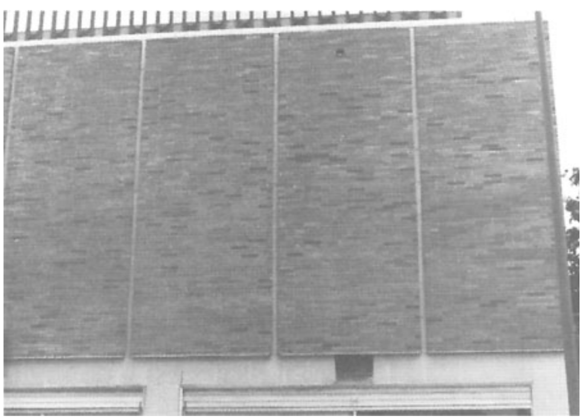


Figure D-13 Brick veneer panels.

wall. Good places to look for the evidence of veneer tile are at door or window openings where the edge of the tile will usually show.

- *Hollow Clay Tile*—The exposed area of a hollow clay tile masonry unit is approximately 6 inches by 10 inches and often has strip indentations running the length of the tile. They are fragile, unreinforced, and without structural value, and usually are used for non-load-bearing walls.

Figure D-14 Hollow clay tile wall with punctured tile.

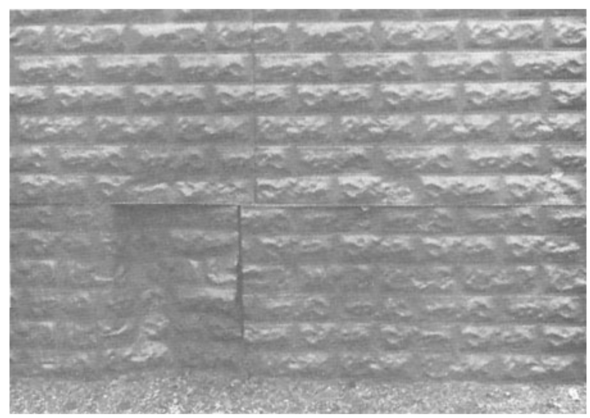


Figure D-15 Sheet metal siding with masonry pattern.

Figure D-14 shows a typical wall panel which has been punctured.

- *False Masonry*—Masonry pattern sidings can be made from sheet metal, plastic, or asphalt material (see Figures D-15 and D-16). These sidings come in sheets and are attached to a structural backing, usually a wood frame. These sidings can be detected by looking at the edges and by their sound when tapped.
- *Cast-in-Place Concrete*—Cast-in-place concrete, before the 1940s, will likely show horizontal patterns from the wooden formwork. The formwork was constructed with wood planks, and therefore the concrete also will often show the wood grain pattern. Since the plank edges were not smooth,

the surface will have horizontal lines approximately 4, 6, 8, 10, or 12 inches apart (see Figure D-17). Newer cast-in-place concrete comes in various finishes. The most economic finish is that in which the concrete is cast against plywood formwork, which will reflect the wood grain appearance of plywood, or against metal or plastic-covered wood forms, which normally do not show a distinctive pattern.

Figure D-16 Asphalt siding with brick pattern.

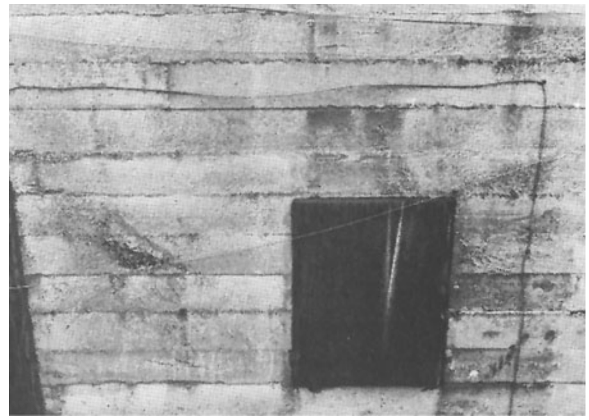


Figure D-17 Pre-1940 cast-in-place concrete with formwork pattern.