5.3

Find and Fix the Hazards

(Wood Frame Homes)

RATIONALE

Relatively simple modifications can greatly increase the safety of a wood frame house. Even students who do not currently live in such houses may at some future time.

FOCUS QUESTIONS

What are some structural earthquake hazards in a typical wood frame home?

What can be done to reduce structural hazards in these homes?

OBJECTIVES

Students will:

1. Assess risk factors in an existing wood frame house.
2. Name several ways to strengthen an existing wood frame construction.

MATERIALS

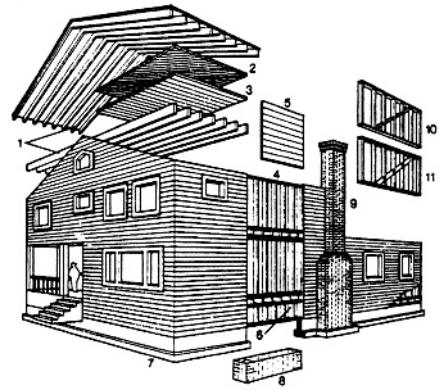
- Classroom map of the local area, from Unit 1
- Master 2.5b, Soil and Geologic Maps and Map Sources (*optional*)
- Student copies of Master 5.3a, Structural Checklist
- Student copies of Master 5.b, Wood Stud Frame Construction
- Flashlights
- Goggles or other eye protection
- Head protection (helmet or hard hat)
- Clip board, paper, and pencil for notes
- Knee pads (*optional*)
- Student copies of Master 5.3c, Strengthening Your Wood Frame House

TEACHING CLUES AND CUES

If possible, prepare your students for this activity and the others in this lesson, then conduct one field trip that combines several of the activities.

This activity emphasizes wood frame houses because they are common single-family dwellings in many parts of the country. If you are not teaching all the lessons in this unit, be sure students understand that other types of structures also pose serious hazards.

PROCEDURE



Teacher Preparation
Contact a local realtor to find a nearby wood frame house that students can visit to conduct their assessment, or arrange with a contractor to visit a building site. If no vacant home is available, plan to use your own home or that of a friend or colleague. Arrange for transportation and permissions as necessary.

A. Introduction
Survey the class, asking: How many students live in wood frame houses? How many have friends or relatives who live in wood frame houses? How many have lived in such houses at some point in their lives? (Be sure students understand that the frame of the house may be wood even if the outside sheathing is stucco, decorative brick, brick veneer, stone, or some other material.) Record a count of student answers on the board.

Tell the class that many homes in regions across the country are constructed of wood frame systems. These wooden structures are lightweight and flexible, and properly nailed joints are excellent for releasing earthquake energy and resisting ground shaking. Nevertheless, frame houses are sometimes damaged by an earthquake, causing a great deal of unnecessary trouble and expense for homeowners. This damage is unnecessary because most often it could have been prevented by some very basic alterations. It pays to find out if your home needs rehabilitation or strengthening and what can be done to lessen the earthquake hazard.

B. Lesson Development
1. Tell students that they are going to play the role of potential home buyers. Each of them has just landed a new job at a higher salary, and has decided to buy a new wood frame house. First, however, they must conduct a visual inspection of each home they consider buying to identify potential earthquake hazards. In this lesson they will learn what to look for in the foundation and other structural components.

2. Ask: What seismic hazard designation has been applied to the area where we live? (In Unit 3, Lesson 3, you noted this information on the classroom local map. It is also available on Master 1.3b, U.S. Earthquake Hazard Map.) Explain that the degree of earthquake risk in any structure depends on where it is located as well as how it is built. If your school is located in a region identified on Master 1.3b as one of low seismic hazard, however, remind students that this map depicts what has happened; it does not predict what *may* happen. Earthquakes can occur anywhere in the world. Moreover, most Americans move several times in the course of their lives.

3. If you did Lesson 2.5, students will also know the soil characteristics of their own region. If this information is not on your classroom map, refer students to local maps of soil characteristics, and

ask them to characterize the soil of the site they will be visiting. (See Master 2.5b, Soil and Geologic Maps and Map Sources.) Emphasize again that the site and the mode of construction interact.

4. Distribute copies of Master 5.3a, Structural Checklist, and Master 5.3b, Wood Stud Frame Construction. Point out the numbered areas on the drawing, and tell students that these are among the things they will be inspecting on their field trip.

5. Travel with your class to the site you have chosen. Direct pairs or small groups of students to conduct inspections. When one group has finished, those students can complete their worksheets while the others proceed.

C. Conclusion

If you are in a moderate- or high-risk area, and your students find that their own homes could be reinforced to better withstand an earthquake, distribute copies of Master 5.3c, Strengthening Your Wood Frame House. Assign students to take home these simple directions for four inexpensive projects. High school students and their parents can follow the steps on these pages to reinforce their wood frame homes.

ADAPTATIONS AND EXTENSIONS

If a majority of your students live in wood frame houses, you may assign this activity as an out-of-class exercise. Cover the information in the introduction with the whole class, then hand out copies of Master 5.3a, Structural Checklist. Ask students to assess the stability of their own homes and complete a report to share with their families and/or their classmates. Have students check on local building laws or talk to the city building inspector. Invite the building inspector to visit your class and talk about local building codes. ▲

Note: *Master 5.3c, Strengthening Your Wood Frame House, is adapted from* An Ounce of Prevention: Strengthening Your Wood Frame House for Earthquake Safety, *with permission from the Bay Area Regional Earthquake Preparedness Project, 101 8th Street, Room 152, Oakland, CA 94607.*

TEACHING CLUES AND CUES

Engineers and architects are the people best qualified to assess the strength of structures and their resistance to earthquakes. If your students have serious concerns, encourage them to discuss with their parents the possibility of bringing in a professional. Even the first modification on Master 5.3c is best undertaken after structural analysis, especially an analysis of foundation soils.

Structural ✓list

Name ____ Date ________________________

Instructions. Rate each component listed on a scale from 1 (good) to 5 (poor).

1. The foundation must react as one unit for maximum earthquake resistance. The best foundations are steel-reinforced concrete that reach down to bedrock. Examine the foundation.

- Is it wood, brick, or concrete?
- Is there any sign of steel reinforcement?
- Are there holes or pits in the foundation?
- Is the concrete powdery or crumbly?
- Are there signs of water damage?
- Are there visible cracks longer than 1 cm?

Rating (Circle one): 1 2 3 4 5

2. The wood plate (also known as a sill plate or a mudsill). This is the first structural wooden member placed on the foundation. Examine the wood plate.

- Is it bolted to the foundation?
- How far apart are the bolts? (The standard spacing is about four feet apart.)
- Is the wood plate fasten or reinforced with metal plates?

Rating (Circle one): 1 2 3 4 5

3. Short stud walls (cripple walls)

- Are they made of wood, brick, or another material?
- Are they braced to resist earthquake-generated lateral forces?
- Are they connected to the wood plates?
- How is the floor frame fastened to the stud wall?

Rating (Circle one): 1 2 3 4 5

4. Exterior walls (shear walls)

- What are the exterior walls made of? (brick, block, wood siding?)
- Are they tied together?
- If the walls are brick, block, or stone, what is the condition of the mortar?
- Are they braced to resist earthquake-generated lateral forces?

Rating (Circle one): 1 2 3 4 5

5. Masonry fireplace chimneys. An unreinforced brick chimney is the weakest part of a house when earthquake shaking begins.

- Does the house have one or more chimneys?
- Is each chimney's foundation part of the house?
- What are the chimneys made of?
- Are they reinforced and designed to be earthquake resistant?

Rating (Circle one): 1 2 3 4 5

6. Utilities and their mountings

- Is the gas main mounted on flexible pipes?
- Is the electrical service firmly mounted?
- Is the main water shutoff accessible?

Rating (Circle one): 1 2 3 4 5

7. Exterior porches

- Does the house have one or more porches?
- Is the porch or porches attached to the house? How?
- Is the foundation of the porch attached to the foundation of the house?

Rating (Circle one): 1 2 3 4 5

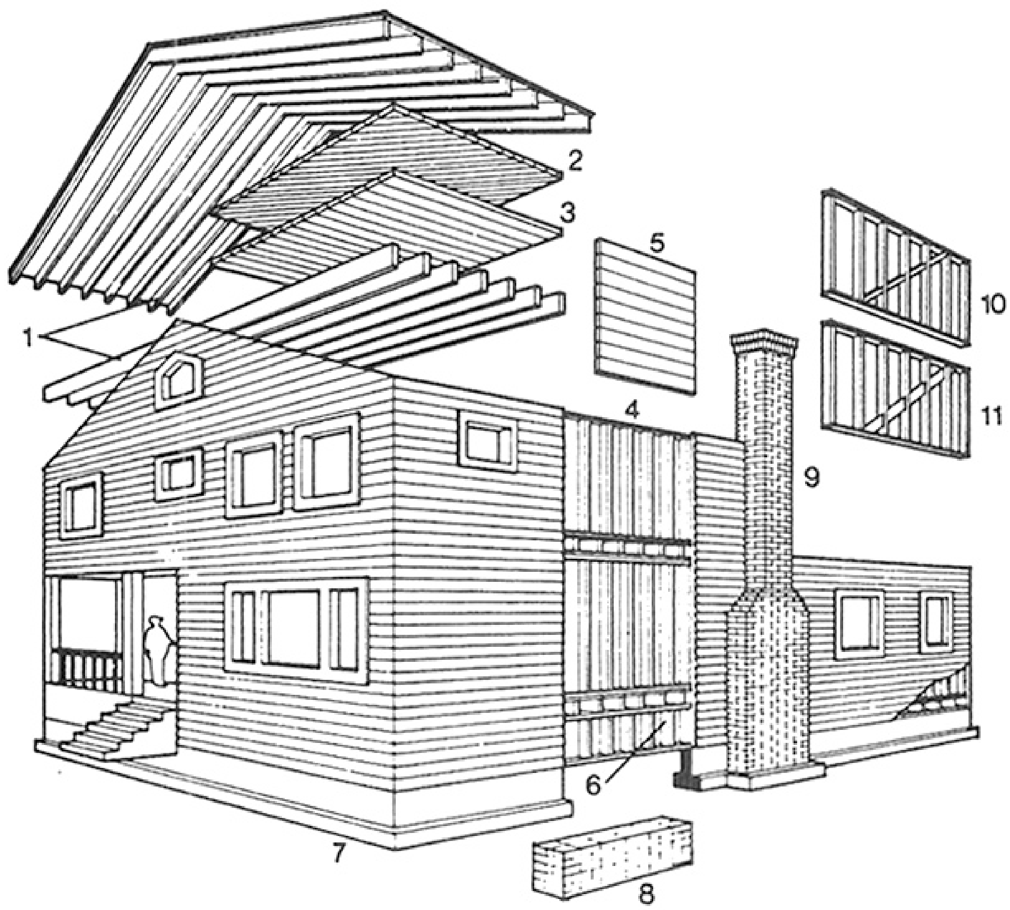
8. Make specific recommendations on how to correct any seismic deficiencies identified.

5.3b MASTER PAGE

Wood Stud Frame Construction

Roof/floor span systems:
1. wood joist and rafter
2. diagonal sheathing
3. straight sheathing

Wall systems:
4. stud wall (platform or balloon framed)
5. horizontal siding



Foundation/ connections:
6. unbraced cripple wall
7. concrete foundation
8. brick foundation

Bracing and details:
9. unreinforced brick chimney
10. diagonal blocking
11. let-in brace (only in later vintages)

Figure 2-7 Wood stud frame construction

Reproduced from Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook, *FEMA Earthquake Hazard Reduction Series 41.*

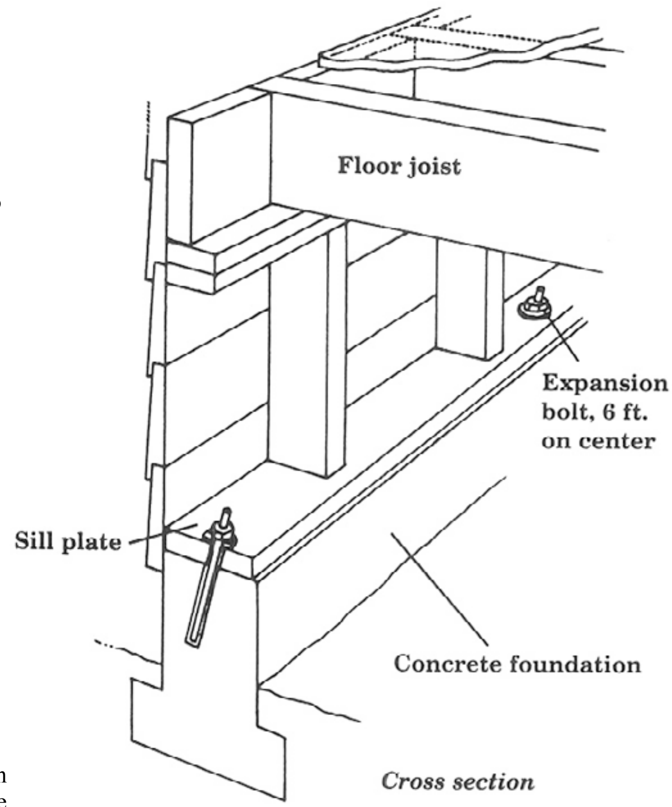
Strengthening Your Wood Frame House: Four Projects

adapted with permission of the Bay Area Regional Earthquake Preparedness Project

Step 1: *Steel Plate Bolting*

Materials and Tools Needed

- 1 cm (1/2 in.) diameter expansion bolts of a style acceptable to the local building department. Length of bolt determined by depth of hole, thickness of sill plate, and a projection of not less than 2.5 cm (1 in.) above sill plate
- Masonry drill bit with carbide tip. Size determined by size and style of expansion bolt.
- Electric rotary impact drill or heavy-duty drill
- Short-handled sledge hammer or carpenter's hammer for setting the bolts.
- 1 cm (3/8 in.) diameter plastic tubing
- Adjustable crescent wrench
- Chalk or lumber crayon
- Measuring tape
- Eye protection
- Noise protection
- Dust mask



Cross section

Installation Instructions for Step 1

1. Lay out bolt locations. Bolts should be spaced at not more than 2 m (6 ft) apart. Begin layout at not less than 10 cm (4 in.) or more than 30 cm (12 in.) from the end of any section of sill plate.
2. Drill holes through the sill plate and into the foundation with a carbide drill bit of the size recommended for the style of expansion bolt used. Drill holes a minimum of 11.5 cm (4.5 in.) into foundation wall.
3. After drilling a hole, clean out the concrete dust by inserting the plastic tubing into the hole and blowing out the dust.
4. Place a cut washer over the bolt so it rests on top of the sill plate. Place the nut on the bolt and turn until the top of the nut is even with the top of the bolt. Insert expansion bolt into the hole until it stops. Using the sledge hammer or carpenter's hammer, strike the top of the hole.
5. Using a crescent wrench, tighten the nut until the sill plate begins to crush under the washer.

Step 2: *Install Blocking at Sill Plate*

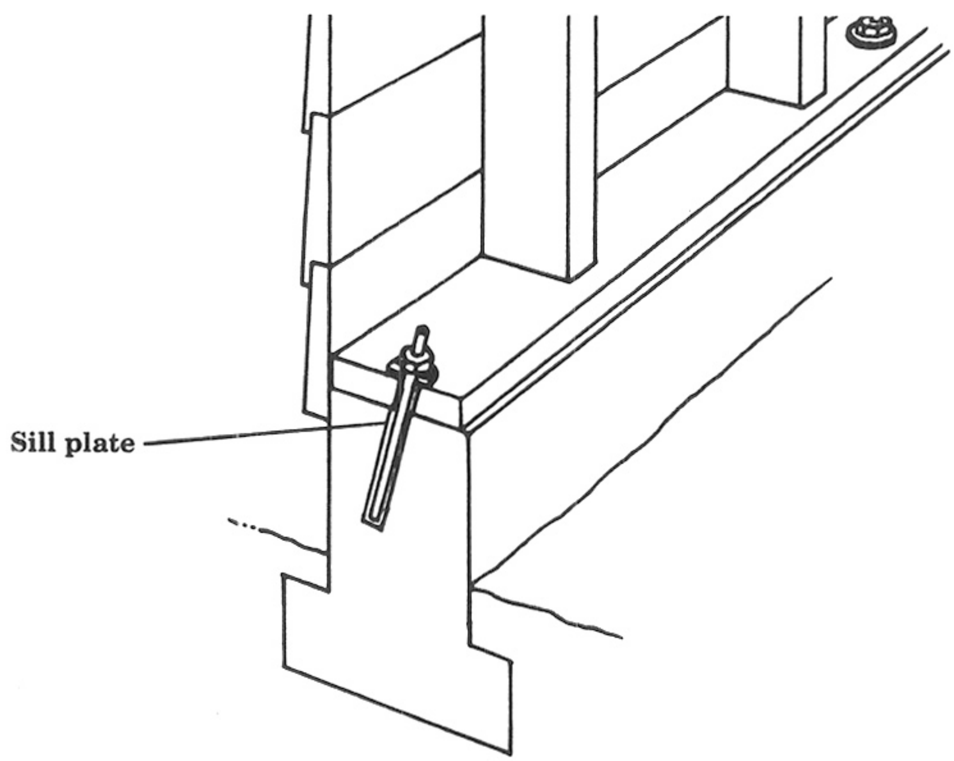
Note: This blocking is necessary only when the depth of the studs is different from the width of the sill plate, such as 2 x 4 studs attached to a 2 x 6 sill. If the stud depth and the sill plate width are the same, skip this step.

Materials and Tools Needed

- Nominal 5 cm (2 in.) thick lumber (actually 4 cm, or 1.5 in. thick) the same depth as the studs
- 16d (16-penny) common nails
- Electric drill to pre-drill holes for nails, if necessary
- 0.2 cm (1/16 in.) diameter drill bits for pre-drilling nail holes and a bit at least 0.2 cm (1/16 in.) larger than the diameter (point-to-point distance across) of the anchor bolt nut
- Carpenter's hammer
- Measuring tape
- Pencil
- Eye protection
- Dust mask

Installation Instructions for Step 2

1. Measure distance between studs.
2. Cut pieces of blocking from 5 cm (2 in.) thick piece of lumber, the same depth as the studs, equal to the distance between studs, that the blocking fits snugly.
3. In those stud spaces, where a new anchor bolt has been installed, mark the bolt location on the bottom of the blocking and drill a hole large enough that the blocking fits over the bolt and rests fully on the sill plate.
4. Nail the blocking to the sill plate with between 3 and 6 16d nails. If blocking begins to split while the nail is driven, remove the nail and drill pilot holes for each nail with the 0.2 cm (1/16 in.) diameter drill bit.



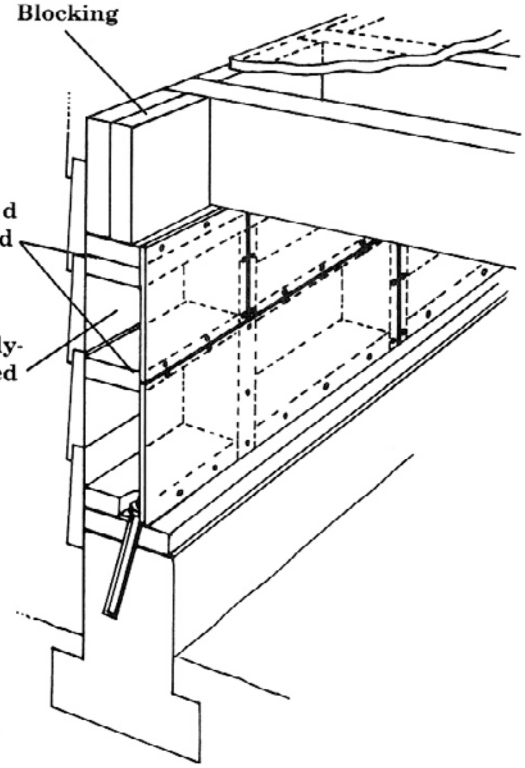
Step 3: *Install Plywood*

Materials and Tools Needed

- 1 cm (3/8 in.) or 1.2 cm (15/32 in.) thick plywood of Structural 1 of CDX grade
- Nominal 5 cm (2 in.) thick lumber (actually 4 cm or 1.5 in. thick) the same depth as the studs. This will be used for blocking, if required.

Note: The size of access to the average crawl space frequently doesn't allow large pieces of plywood. You may need to use two or more smaller pieces of plywood. When multiple pieces are used to cover the height of the wall, blocking must be installed at the joint and completely nailed. If a single piece of plywood can be installed the full height of the reinforcing wall, blocking will not be necessary.

- 8d common nails for use with 1 cm (3/8 in.) plywood
- 10d common nails for use with 1.2 cm (15/32 in.) plywood
- 16d common nails for use with blocking, if required
- Electric circular saw
- Electric drill
- 0.2 cm (1/16 in.) diameter drill bit for pre-drilling nail holes if blocking is required
- Nail gun or carpenter's hammer
- Measuring tape
- Chalk, lumber crayon or pencil
- 4 cm to 5 cm (1.5 in. to 2 in.) diameter hole saw



Installation Instructions for Step 3

1. If access to the crawl space under the house is such that full-width sheets, or sheets cut to the height of the cripple studs, will not fit, cut plywood sheets lengthwise to a width not less than 46 cm (18 in.).

2. If sheets need to be cut, blocking will be necessary. Cut the 5 cm (2 in.) nominal thickness lumber to fit snugly between the studs. Nail each block to the studs with 2 16d nails at each end. Nails should be driven into the side of the stud. Pre-drilling for the nails will make this operation easier. Blocking should be installed at the same height for the full length of the plywood sheet.

3. Starting at a comer, measure across the studs to find a stud where the sheets of plywood can butt. In order to do this, find the stud closest to, but not less than 1.2 m (4' ft.) or closest to, but not more than 2.4 m (8 ft.) from the corner. Measure the location of all ventilation vents and cut out holes in the plywood to match the vents.

4. Mark the location of each stud at the top plate and on the foundation wall with chalk or lumber crayon.

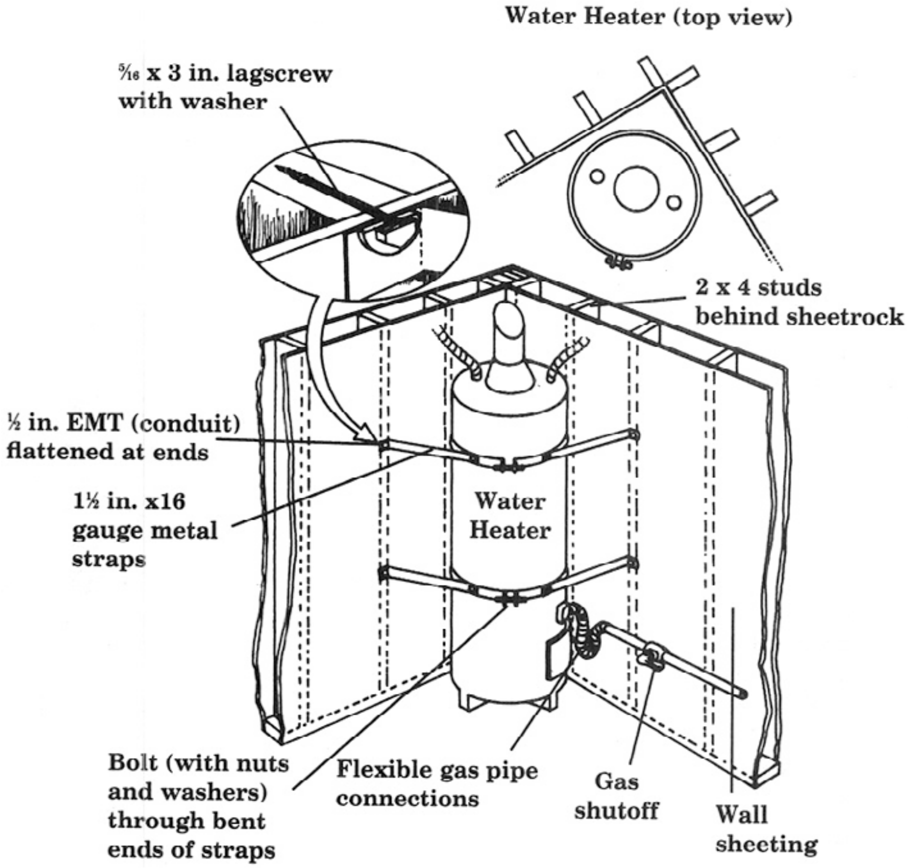
5. After cutting the plywood to fit, lay it up against the studs and hammer a nail in each comer of the plywood to hold it in place. Using a nail gun, or a carpenter's hammer, place a nail every 10 cm (4 in.) around the perimeter of the plywood sheet. Then place a nail every 15 cm (6 in.) along each stud. Use the nails appropriate for the thickness of the plywood.

6. Once the plywood has been fully nailed, drill a 4 cm to 5 cm (1.5 in. to 2 in.) diameter hole above and below the blocking.

Step 4: *Strap Water Heater*

Materials and Tools Needed

- Two 1.8 m (6 ft.) lengths of 4 cm (1.5 in.) gauge pre-drilled strap
- One 3.1 m (10 ft.) length of 1 cm (.5 in.) EMT tube (conduit)
- Four 1 cm x 7.5 cm (5/16 in. x 3 in.) lag screws with washers
- Two 1 cm x 2 cm (5/16 in. x 3/4 in.) hex head machine bolts with 1 nut and 2 washers each
- Two 1 cm x 3 cm (5/16 in. x 1-1/4 in.) hex head machine bolts with 1 nut and 2 washers each
- Electric drill
- Tape measure
- Hammer
- Hacksaw
- Crescent wrench
- Vise or clamp
- Power drill
- 1 cm (3/8 in.) drill bit
- Center punch



Installation Instructions for Step 4

1. Mark water heater at 15 cm (6 in.) from top and about 46 cm (18 in.) up from bottom. Transfer these marks to the wall. Locate the studs in the wall on both sides of the water heater.

2. Drill a 0.5 cm (3/16 in.) hole 7.5 cm (3 in.) deep through the wall sheathing and into the center of the wood studs at the four marks made in step 1.

3. Measure around the water heater and add 7.5 cm (3 in.) to the measurement. Using a hacksaw, cut the two 4 cm (1.5 in.) 16-gauge metal straps to this length for encompassing water heater.

4. Mark 4 cm (1.5 in.) from each end of metal straps, insert them in a vise, and bend the ends outward to approximately a right angle. Bend the straps into a curve.

5. Measure the distance from a point midway on each side of the water heater to the hole drilled in the wan (probably two different lengths). Add 4 cm (1.5 in.) to these measurements. Using a hacksaw, cut two pieces of tube to each of these two lengths.

6. Using a hammer, flatten approximately 4 cm (1.5 in.) at each end of the four pieces of tubing by laying the tube on a flat metal or concrete surface and striking with the hammer. Be sure you flatten both ends on the same plane.

7. Insert the flattened ends of the tubes, one at a time, into a vise or clamp. With the hammer and center punch make a mark 2 cm (3/4") from each end at the center of the flattened area of the tube. Drill 1 cm (3/8 in.) holes in each end of all four tubes (8 holes). Be sure tubes are clamped down while drilling. Bend each end to about 45 degrees.

8. Wrap the straps around the heater and insert a 1 cm x 3 cm (5.16 in. x 1.25 in.) bolt with washers into the bent ends. Tighten nuts with fingers. Insert 1 cm x 2 cm (5/16 in. x 3/4 in.) bolts through straps from the inside at the mid-point on each tube strut and insert on hole in the wall stud. You may need to tap the lag screw gently into the hole to start it, then tighten with crescent wrench.

9. Adjust the straps to the proper height and tighten nuts snugly. If the nuts are too tight, the straps could tilt the heater.

Note: *Flexible gas and water supply lines to the water heater will greatly reduce the danger of water pipe leaks and fire or explosion from a gas leak after an earthquake. If your water heater does not have a flexible gas line, contact a licensed plumber to install one. These instructions are for a 30 to 40 gallon water heater within 30.5 cm (12 in.) of a stud wall.*

5.4

Rapid Visual Screening (RVS) in the Community

RATIONALE

Students will perform an informal RVS (rapid visual screening) to determine the nonstructural hazards to people and property that could be caused by buildings in their community during an earthquake.

FOCUS QUESTIONS

What buildings in my town or city might pose a serious risk of casualties, property damage, and/or severe curtailment of public services, if a damaging earthquake happened here?

OBJECTIVES

Students will:

1. Conduct a sidewalk survey of nonstructural building hazards in their community.
2. Record their observations on data collection forms.

MATERIALS

- Transparency from Master 1.3b, U.S. Earthquake Hazard Map
- Classroom wall map of your own region which includes seismic hazard designations. This may have been prepared in Unit 1.
- Overhead projector (optional)
- Transparency made from Master 5.4a, Nonstructural Hazards
- Student copies of Master 5.4a, Nonstructural Hazards
- Student copies of Master 5.4b, RVS Observation Sheet, six for each team
- Clipboard for holding observation sheets and drawing paper
- Pens or pencils
- Blank drawing paper
- Straightedge or ruler for drawing sketches

VOCABULARY

Canopy: a covered area that extends from the wall of a building, protecting an entrance.

Cantilever: a beam, girder, or other structural member which projects beyond its supporting wall or column.

Cladding: an external covering or skin applied to a structure for aesthetic or protective purposes.

Cornice: the exterior trim of a structure at the meeting of the roof and wall.

Glazing: glass surface.

Masonry veneer: a masonry (stone or brick) facing laid against a wall and not structurally bonded to the wall.

Parapet: part of a wall which is entirely above the roof.

Portico: a porch or covered walk consisting of a roof supported by columns.

Veneer: an outside wall facing of brick, stone, or other facing materials that provides a decorative surface but is not load-bearing.

- Camera, preferably instant (*optional;* if available, replaces sketches)
- Tape or stapler, for affixing photo (*optional*)
- Red marking pen

PROCEDURE

Teacher Preparation

Select site(s) for the class field assignments, choosing the nearest large concentration of buildings. Students may choose buildings to survey or they may be assigned.

A. Introduction

Tell students that they are going to assume the role of building inspectors in completing an informal sidewalk survey of buildings in their community.

B. Lesson Development

1. Ask students whether their region of the country is thought to be at low, moderate, or high risk for earthquakes. If you do not have this information on your classroom map, project the transparency made from Master 1.3b, U.S. Earthquake Hazard Map. If your school is located in a region pictured on the map as one low seismic hazard, remind students that they may not always live where they live now, and other natural disasters may affect the buildings.

2. Tell students that a building may be structurally sound but its exterior decorations may create a hazard. These are called nonstructural hazards. Project the transparency made from Master 5.4a, Non-structural Hazards, and elicit student descriptions of nonstructural hazards on the outside of buildings in the drawing.

3. Tell students that for the purpose of this exercise, they will assume that a major earthquake is likely in their area in the next several years. They will take a walk and record their observations of nonstructural hazards.

4. Assign each student a partner. Distribute six copies of Master 5.4b, RVS Observation Sheet, to each pair, and ask each pair of students to complete the following steps for six buildings, noting all the information on their observation sheets.

a. Record a description of the building and its address or location.

b. Note materials used in construction.

c. Estimate the year of its construction.

d. Record its size (number of floors, area, shape, and other information).

e. Determine the current use (business, apartments or other).

f. List the readily visible nonstructural hazards.

g. Sketch or photograph the building.

5. Back in the classroom, suggest ways for students to fill in any miss- ing information. Individuals may volunteer to call their mentors in the chamber of commerce, the local building department, or the public works department. Students could also call the firm that developed or manages a building. Then instruct all the students who filled out forms on the same building to compare their data and discuss any discrepancies. The goal of this process should be an assessment of each building surveyed that represents the students' best consensus.

C. Conclusion

On the classroom local map you started in Unit 1, use a red marker to circle any block or group of blocks where concentrated nonstructural damage could be expected in the event of an earthquake. Open a class discussion of what students have learned. If students have not already expressed an opinion, ask if the sidewalks they traveled would be safe places to be during an earthquake. Generally, the most dangerous place to be is at building exits and directly adjacent to buildings (on the sidewalks, for example).

ADAPTATIONS AND EXTENSIONS

1. If a structural engineer is present or structural information is available from the building manager, students may also informally judge which buildings could be expected to withstand heavy earth- quake shaking.

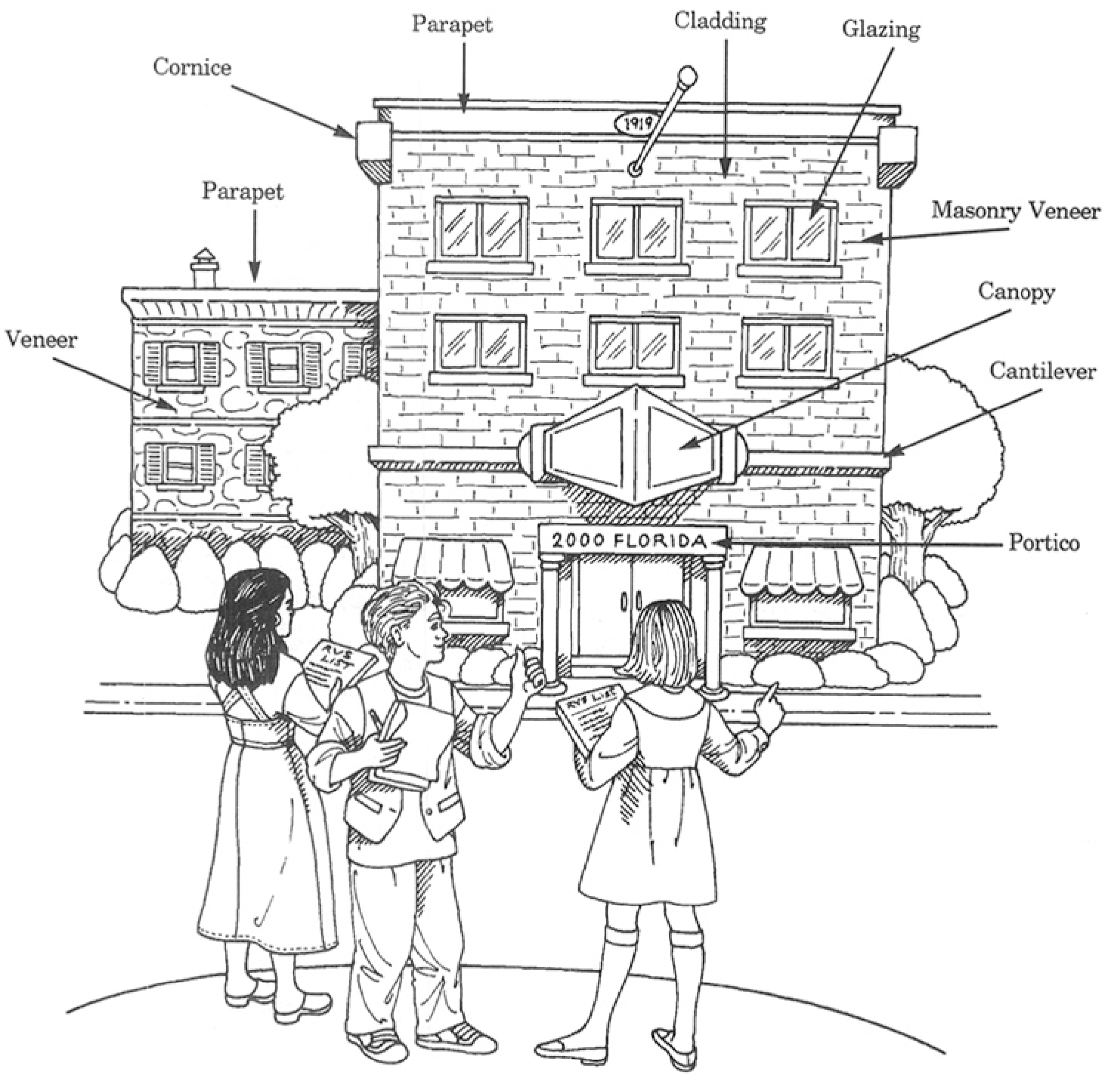
2. If structural information is available from the building manager, students may also list the type of building construction used (wood, steel, masonry, cement, or other building materials.) ▲

Nonstructural Hazards

Name ____ Date ____________________

Nonstructural Hazards (key)

Date:



RVS Observation Sheet

Name ____ Date ____________________

1. Building name ____________________
2. Street address ____________________
3. Materials used in construction ____________________
4. Year of construction ____________________
5. Size (number of floors), area, and shape ____________________
6. Current use ____________________
7. List of nonstructural hazards (see Master 5.4a and vocabulary for illustrations and definitions)

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________

h. ____________________

i. ____________________

j. ____________________

k. ____________________

l. ____________________

m. ____________________

Sketch building or attach photo.

(Continue on back if necessary)

5.5

Are the Lifelines Open?

Critical Emergency Facilities and Lifeline Utility Systems

RATIONALE

How well a community recovers from a damaging earthquake depends on the survival of critical emergency facilities and major utility systems (“lifelines”). In this lesson, students resume their focus on community preparedness.

FOCUS QUESTIONS

Where are the critical emergency facilities and major lifelines in my community, and how vulnerable are they?

How would my community survive a damaging earthquake?

OBJECTIVES

Students will:

1. Name and locate the critical emergency facilities and lifelines in their community, and evaluate their sites for geological hazards.
2. Contact civic leaders, heads of emergency facilities, and public utility officials to learn about their emergency plans, or renew existing contacts.
3. Report to the class and the community on what they have learned.

MATERIALS

■ Brainstorming list of survival necessities from Unit 1, Lesson 2

■ Master 5.5a, Lifelines and Critical Emergency Facilities

■ Back of Master 5.5a, Problem Areas

■ Master 5.5b, A Chain of Disasters

■ Local map(s) showing locations of major emergency facilities and lifeline systems

■ Classroom local map developed in Lesson 1.3, with notes on soil conditions from Lesson 2.5

■ Red marking pen

■ Local telephone directories

VOCABULARY

Lifeline: a service that is vital to the life of a community. Major lifelines include transportation systems, communication systems, water supply lines, electric power lines, and petroleum or natural gas pipelines.

TEACHING CLUES AND CUES

If your students have not developed a map of your own area that contains information on fault and soil types, use the maps on Master 2.5c to show them how this kind of information is presented visually.

PROCEDURE

Teacher Preparation
Read Master 5.5a, Lifelines and Critical Emergency Facilities. Decide how you will group students for this activity. If necessary, combine categories, such as natural gas and petroleum fuels, so that together the groups cover all the areas. For each group, make one copy of the local map(s) with locations of major emergency facilities and lifeline systems. Also make one copy of a local map showing geological hazards, if your classroom map does not already have this information.

A. Introduction

Display the list of necessities for survival that students developed in Unit 1, Lesson 1. Review the list with the class and ask if they have anything to add, or if anything they included at that time now seems less than essential. When the class has reached consensus, display Master 5.5a or distribute copies. Does the list include anything students have omitted? To reinforce the connections among the many kinds of damage earthquakes can cause, display Master 5.5b, A Chain of Disasters. Have students revise their list of necessities again to incorporate anything they may have missed. Emphasize the importance of emergency facilities—such as hospitals, fire stations, and police departments—and of public utilities—such as telephone lines, electric power systems, water supply systems, and transportation into and out of the affected area.

B. Lesson Development

1. Divide the class into small groups and assign one or more of the 10 systems listed on Master 5.5a to each group. Individual student's responsibilities will reflect their mentor's areas.

2. Distribute one set of maps to each group. Instruct students to compare the lifeline maps to the classroom local map and note any geological features in their service area that might constitute a hazard. Invite them to develop their own system for indicating relative degrees of risk on the lifeline maps: coding by color, by number, or by different kinds of symbols, for example. When they have worked out a system that satisfies everyone, students can transfer this information to the classroom map.

3. Instruct students in each group to plan reports on the community's plans for surviving the first 72 hours after an earthquake. They may need to renew their contacts with key people in their assigned service areas and schedule phone interviews. Give students class time to prepare lists of questions for their interviews. Then ask each group to exchange its list with another group and critique the questions.

4. When every group's questions have been reviewed and students are satisfied that they will elicit the necessary information, ask students to make the phone calls outside of class and take notes on what they learn.

5. The next time the class meets, allow 10 minutes for students in each group to pool their information. Then invite a representative

TEACHING CLUES AND CUES

If your community is in one of the parts of the country where earthquakes have not been recorded, students can learn about preparations for other kinds of natural hazards, such as floods, hurricanes, and tornadoes. In many cases the same systems would be affected and the some kinds of preparations will have been made. Fire departments will be an excellent source of emergency information.

TEACHING CLUES AND CUES

Emphasize that every student is to make at least one phone call. Calling several people in each system will increase the amount and quality of information students receive. Students are also likely to find what they learn reassuring—for example, that local hospitals have emergency backup generators.

from each group to report to the class on how the system that group studied would operate during an emergency.

C. Conclusion

On the classroom local map, use red ink to indicate any lifelines or critical facilities that may be at high risk in the event of an earthquake or other natural disaster.

Discuss students' reactions to what they have learned. If they are pleased with the community's level of preparedness, overall or in any of the separate systems, encourage them to write letters of congratulation to the appropriate officials or to the newspaper. If they are concerned that preparation seems inadequate, or if they have concerns about siting and geological hazards, they may write letters expressing their concern and recommending improvements.

Direct students to put their notes from this activity away in a safe place. They will need this information again in the Unit 6 role-playing activity.

ADAPTATIONS AND EXTENSIONS

1. If you know that your area is one of low seismicity, try to locate flooding maps, erosion maps, or maps of other types that are particularly relevant to your area. Have students learn about 100-year floods, the effect of windstorms over time, or other hazards that are specific to your community.

2. Provide maps of the state or the region surrounding your local area. Challenge students to identify alternate emergency facility locations and alternate transportation routes and map them out for classroom display. ▲

Lifelines and Critical Emergency Facilities

A. Critical Emergency Facilities

1. Medical facilities: hospitals, blood banks

2. Emergency response facilities: police stations, fire departments

3. Local office: emergency operations center

B. Lifeline Utility Systems

1. Transportation systems: highways, freeways, bridges, airports, railroads, docks and marinas

2. Communication systems: telephones, radio, television, newspapers

3. Water supply: dams and reservoirs, aqueducts, distribution lines

4. Waste water: treatment plants, holding tanks, collection lines, effluent lines

5. Electric power: transmission towers and lines, switching stations, power generating plants, local distribution lines

6. Natural gas: holding tanks, pipeline distribution lines

7. Petroleum fuels: refineries, tank farms, pipelines

Problem Areas

Name ____ Date: ______________________

1. If electricity is cut off, electric appliances will not function. Without refrigeration, large amounts of food and medicine will be liable to spoil. Gasoline pumps and auto service stations win be unable to pump gasoline. Without power, airport control towers will have to rely on backup systems. Airports may function at limited capacity or not at all.

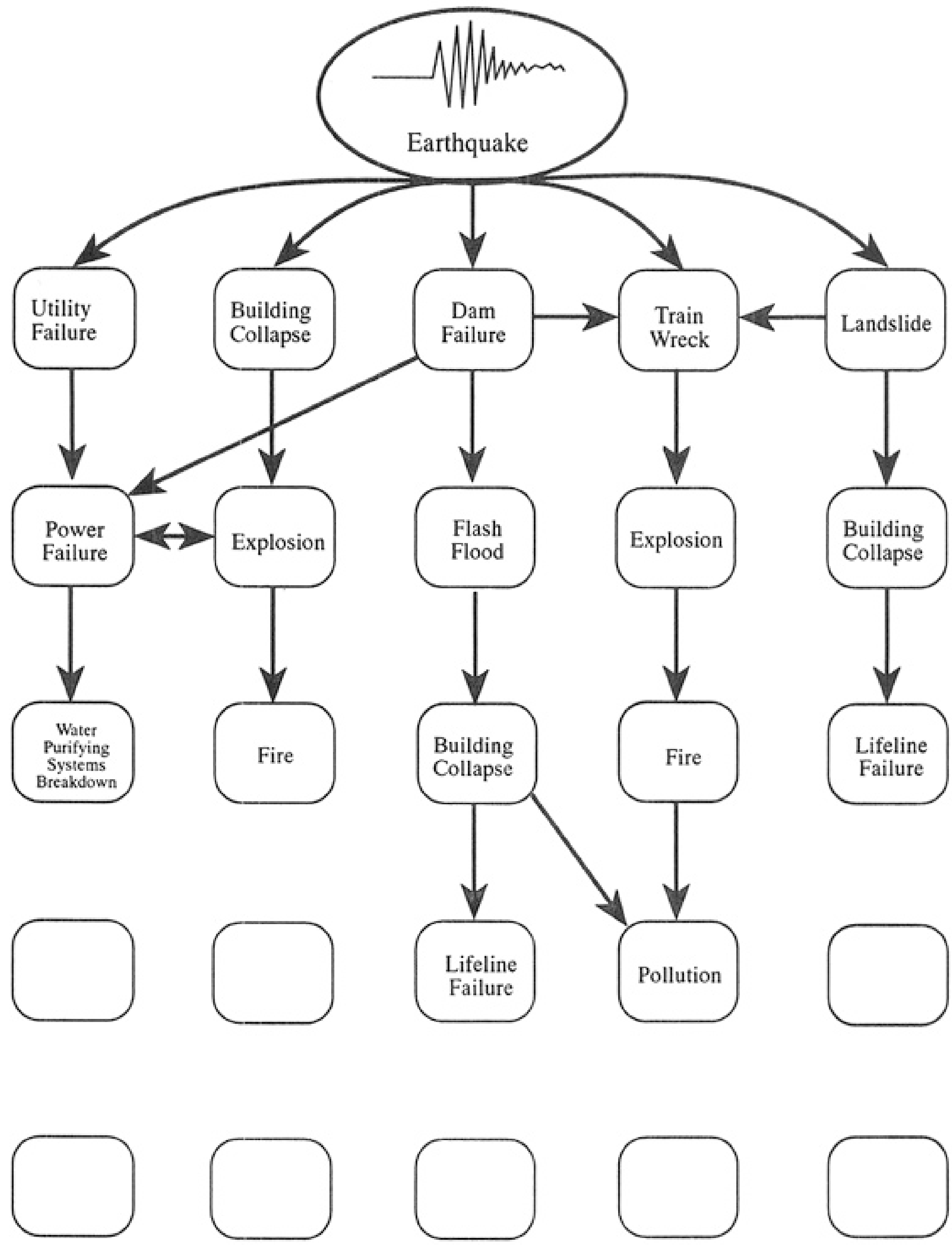
2. If water distribution systems fail, the community will have no clean drinking water. Water may be limited or unavailable for fighting fires.

3. If hospitals are damaged, they will not be able to provide care and treatment for injuries and casualties. Even if a building's structure survives, its services may be limited by lack of water and electricity and lack of transportation. Modern hospitals rely heavily on technology.

4. Rupture of petroleum fuel or natural gas pipelines may cause serious fires in the community and outlying areas, as well as shortages of heat and power.

5. If sewer systems fail, lack of sanitation may cause epidemics, such as cholera.

A Chain of Disasters



Students may fill in blanks and add lines.

Books

American Red Cross, Los Angeles Chapter. (1985). *The Emergency Survival Handbook.* In English and Spanish. A simple, practical, and easy-to-use guide; includes disaster planning, first aid, and survival skills.

Bay Area Regional Earthquake Preparedness Project (BAREPP). (1990). *An Ounce of Prevention: Strengthening Your Wood Frame House for Earthquake Safety.* Oakland, CA: CA-OES, 415-540-2713.

Federal Emergency Management Agency (FEMA). (September 1986). *"Family Earthquake Safety—Home Hazard Hunt and Earthquake Drill."* FEMA 113. Tips on safe places and danger zones in the house, earthquake drills, and what should be done before and after.

Federal Emergency Management Agency (FEMA). (1990). *"Guidebook for Developing a School Earthquake Safety Program."* FEMA 88. Washington DC: FEMA Publications, 500 C St., SW, Washington, DC 20472. This 50-page guide covers earthquake hazard identification; drills; response, communication, & shelter planning.

Federal Emergency Management Agency. (1993). *"Identification & Reduction of Nonstructural Hazards in Schools."* FEMA 241.

Federal Emergency Management Agency. (October *1990). Non-Technical Explanation of the NEHRP Recommended Provisions.* FEMA 99. Washington, DC: Intended to help individuals assess how earthquakes affect buildings & how enforcement of building codes helps to minimize loss.

Federal Emergency Management Agency. (July 1988). *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook*. FEMA 154. Washington, DC: FEMA Describes the technique of rapid visual screening of buildings for potential seismic hazard.

Federal Emergency Management Agency. (1989). *Seismic Considerations: Elementary and Secondary Schools.* FEMA 149. Washington, DC: Building Seismic Safety Council. Covers the costs & benefits of applying seismic design in the construction of new school facilities. Explains how damage occurs to nonstructural components & building contents.

Helfant, David Benaroya. (1989). *Earthquake Safe: A Hazard Reduction Manual for Homes.* Berkeley, CA: Builders Booksource. A little book with reasonable explanations, detailed procedures, and plentiful illustrations.

Lagorio, Henry J. (1990). *Earthquakes.* New York: John Wiley and Sons, Inc. An architect's guide to nonstructural seismic hazards. Focuses on site planning, building design, urban planning and design, rehabilitation of existing buildings, and disaster recovery and reconstruction.

Matthys, Levy, and Salvadori, Mario. (1992). *Why Buildings Fall Down.* New York and London: W.W. Norton and Company.

Wesson, R.L., and Wallace, R.E. (1985). "Predicting the Next Great Earthquake in California." *Scientific American* 252, 2: 35-43.

Nonprint Media

Microstation, V. 5. A computer-assisted drafting program for student use. Order from Intergraph Corporation, Huntsville, AL, 1-800-345-4856. $150 with educational discount.

Reducing Nonstructural Earthquake Damage—A Practical Guide for Schools. Video (13:00 min). *Schools & Earthquakes—Building Schools to Withstand Earthquakes.* Video (14:27 min). Both available from FEMA.

Note: *Inclusion of materials in these resource listings does not constitute an endorsement by AGU or FEMA.*