ATC 20-1

Field manual: postearthquake safety evaluation of buildings

Second Edition

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ATC-20-1

Field Manual: Postearthquake Safety Evaluation of Buildings

Second Edition

by
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2005

Preface

In July 1987, the California Governor's Office of Emergency Services (OES), the California Office of Statewide Health Planning and Development (OSHPD), and the Federal Emergency Management Agency (FEMA), jointly awarded the Applied Technology Council a contract to develop procedures for evaluating building safety after earthquakes. This led to the development of the ATC-20 report *Procedures for Postearthquake Safety Evaluation of Buildings*, which was published in 1989.

ATC-20 provides procedures and guidelines for the safety evaluation of damaged buildings. These procedures and guidelines are written specifically for volunteer structural engineers, as well as building inspectors and structural engineers from city building departments and other regulatory agencies, who would be required to make on-the-spot evaluations and decisions regarding the continued use and occupancy of damaged buildings.

To provide the ATC-20 methodology in a concise, easy-to-use field reference document, this Field Manual was developed as part of the ATC-20-1 project, a follow-on project sponsored by OES and OSHPD. The Field Manual is intended to be taken into damaged areas and used by those trained in the ATC-20 methodology.

Additional discussion and background on the building evaluation methodology used in this manual is given in the ATC-20-2 report *Addendum to the ATC-20 Postearthquake Building Safety Evaluation Procedures* (1995), prepared by the Applied Technology Council. It is desirable that users of this manual be familiar with both ATC-20 and ATC-20-2. In addition, the ATC-20-3 report, *Case Studies in Rapid Postearthquake Safety Evaluation of Buildings*, published in 1996, provides more than 50 detailed case studies of safety evaluation on a wide range of building types and damage conditions.

The first edition of the ATC-20-1 Field Manual was published in 1989. This second edition has been updated to include:

- the RESTRICTED USE placard, which was introduced in 1995 (replacing the LIMITED ENTRY placard),
- updated evaluation forms, which were also introduced in 1995,
- new examples,
- more information on steel moment-frame buildings,
- a chapter on mobile homes and manufactured housing,
- guidance on aftershocks and entering damaged buildings,
- new information on barricading, and
- resources available on the internet pertaining to postearthquake safety evaluation.

R. P. Gallagher Associates, Inc., a structural and earthquake engineering firm with experience in the seismic evaluation of buildings, served as the project subcontractor and prepared the original Field Manual and this updated version. Ronald P. Gallagher served as Principal-in-Charge.

Members of the Project Engineering Panel who provided overall review and guidance for this second edition of the ATC-20-1 Field Manual were: David R. Bonneville, Nick Delli Quadri, Maryann T. Phipps, Richard A. Ranous, James E. Russell, William E. Staehlin, and Zan Turner. RDD Consultants prepared the manuscript for publication.

Christopher Rojahn
ATC Executive Director

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1. Introduction

Purpose and Scope

This manual is a field reference document to be used when making postearthquake building safety evaluations. These evaluations are made to determine whether damaged, or potentially damaged, buildings are safe for continued use, or if entry should be restricted or prohibited. It should be noted that while the scope of this manual deals primarily with structural safety, it also considers and provides guidelines for dealing with other hazards (e.g., downed power lines, hazardous material spills, blocked fire exits, and damaged elevators) that might be encountered.

This manual is intended to be used by building officials, building inspectors, structural engineers, and others involved in postearthquake building inspections. Procedures are given for two of the three ATC-20 methods of safety evaluation (Rapid Evaluation and Detailed Evaluation). Advice is provided on evaluating structural, geotechnical, and nonstructural hazards. The basic approach is to provide guidance on where to look for damage and give advice on how to rate the safety significance of any damage or hazardous condition found.

Other topics covered in the manual include inspection of essential facilities (Chapter 13), dealing with owners and occupants of damaged buildings (Appendix B), field safety for those making damage assessments (Appendix C), and entry into damaged buildings (Appendix D).

2. Overview of Building Safety Evaluation

Safety-Evaluation Procedures

There are three distinct safety-evaluation procedures within the ATC-20 methodology. These are:

1. Rapid Evaluation,
2. Detailed Evaluation, and
3. Engineering Evaluation.

The use of the three different procedures is outlined in Figure 2-1.

Following is a brief description of each safety-evaluation procedure, along with an estimated inspection time per building. Each method is used for a specific purpose and should be done by qualified personnel (See Table 2-1).

Rapid Evaluation (typically 10–30 minutes per building) is the first, and many times the only, safety evaluation performed. These evaluations are often cursory in nature because there are insufficient personnel available to perform more thorough inspections.

Detailed Evaluation (typically 1–4 hours per building) is a thorough visual examination of a damaged building and is often, but not always, performed after an initial Rapid Evaluation. Detailed Evaluations usually begin after sufficient numbers of structural engineers and other specialists become available, and it may be the only evaluation performed. Often these evaluations begin a day or more after the event.

Engineering Evaluation (typically 1–7 days or more per building) is performed on questionable and badly damaged buildings that have been turned over to the owner's engineer for further evaluation and

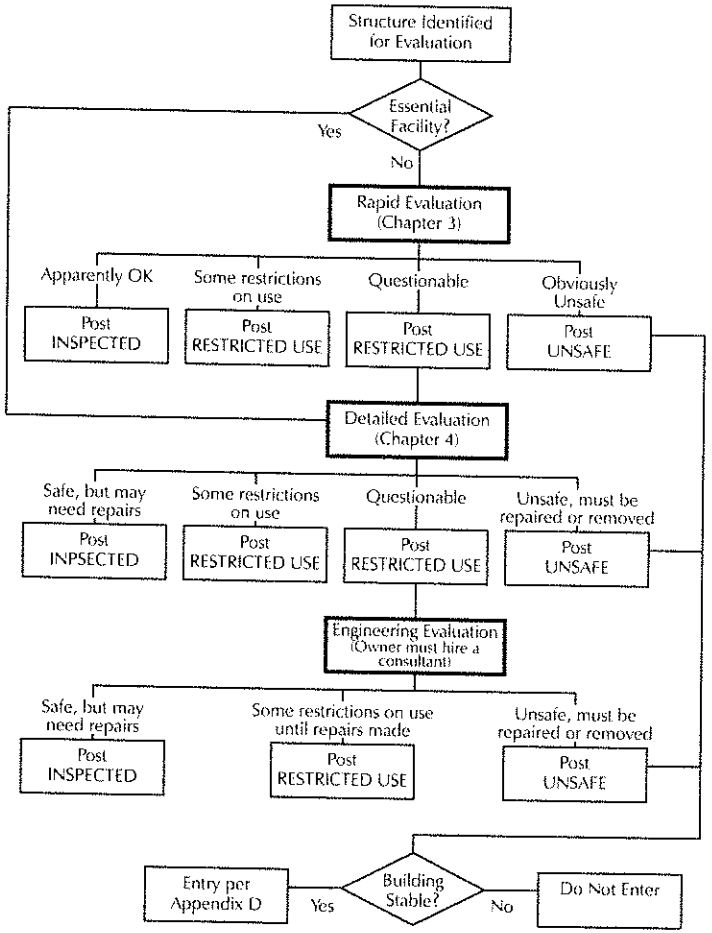


Figure 2-1 Flowchart of the normal building safety evaluation and posting process. Refer to "Changing a Posting" on page 11 for information regarding changing of posting classifications.

repairs. In some situations, the owner's engineer may take over after the Rapid Evaluation stage and no Detailed Evaluation is done.

Table 2-1. ATC-20 Building Evaluation Methods

Method	Suggested Personnel	Objective
Rapid Evaluation	Building inspectors Civil/Structural engineers Architects Disaster workers	Rapid assessment of building safety. Used to quickly post obviously unsafe and apparently safe structures and to identify necessary restrictions on building use.
Detailed Evaluation	Structural engineers[a,b]	Thorough visual evaluation of a building. Used to evaluate questionable buildings, to identify necessary restrictions on building use, or to identify the need for an Engineering Evaluation.
Engineering Evaluation	Structural engineering consultant[a]	Detailed engineering investigation of a damaged building for purposes of determining the extent of damage and/or how to stabilize and repair the building.

a. Geotechnical or hazardous material specialists are required for assessment of geotechnical hazards or hazardous material spills.
b. Ideally two structural engineers. However another good team is a structural engineer and a building inspector. If structural engineers are not available, building inspectors and architects can be used.

Right to Inspect

ATC-20 procedures assume that local building departments have the authority to inspect buildings, even apparently undamaged structures, in the postevent period.

Posting System

After undergoing safety evaluation, buildings are posted with one of three placards: INSPECTED, RESTRICTED USE, or UNSAFE. These placards are shown in Figure 2-2. This posting lets owners, occupants, and the public know whether inspected buildings are safe for use. The system used for posting a building and the definition of each posting category are summarized in Table 2-2. Full-size versions of the placards may be downloaded from the ATC website (see Appendix F).

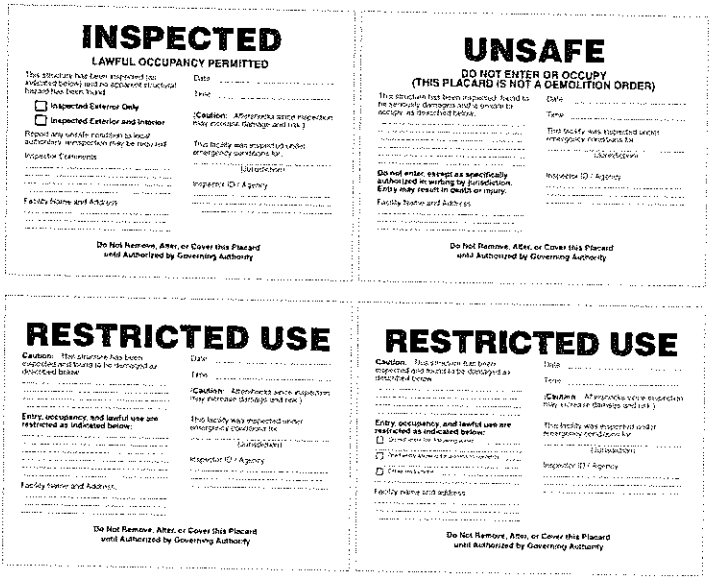


Figure 2-2 ATC-20 posting placards. There are two versions of the RESTRICTED USE placard. One has a place for restrictions to be entered. The other has check boxes and preprinted restrictions. Full-sized copies of the placards can be downloaded from *www.atcouncil.org*.

In addition to posting a building, it may be necessary to designate areas for which access is restricted. These can be hazardous areas inside or outside the building. For example, if a badly cracked parapet is observed, the area on the ground outside the building and within potential striking distance must be barricaded to prevent entry. If necessary, the restricted area can be formally posted using the UNSAFE placard.

Table 2-2. Building Safety-Evaluation Classifications

Posting Classification[a]	Description[b]
Inspected (Green)	No apparent hazard is found, although repairs may be required. The original seismic resistance is not significantly decreased. **No restriction on use or occupancy.**
Restricted Use (Yellow)	A hazardous condition exists (or is believed to exist) that requires restrictions on the occupancy or use of the structure. **Entry and use are restricted as indicated on the placard**[c].
Unsafe (Red)	Extreme structural or other hazard is present. There may be imminent risk of further damage or collapse from creep or aftershocks. **Unsafe for occupancy or entry, except as authorized by the local building department**[c,d].

a. Colors indicated are recommended placard colors.
b. See also Chapter 4 for additional definitions of Inspected, Restricted Use and Unsafe.
c. See Appendix D for guidelines on entry into damaged buildings.
d. Posting a building Unsafe is not a demolition order.

Posting and Barricading Procedures

After the safety evaluation of a building has been completed, post the structure using the following procedures and criteria:

1. Place the appropriate placard in a clearly visible location near the main entrance. Place additional placards at all other entrances to a building classified Restricted Use or Unsafe (except single-family dwellings).

2. There can only be one posting classification per building. Different occupancies in the same building cannot be posted differently, although a Restricted Use posting may indicate different restrictions for different parts of a building.

3. Restrictions must be specified for a RESTRICTED USE placard to be considered complete. Table 2-3 indicates typical restrictions placed on building use, but other restrictions can also be used.

4. If an area is unsafe and should not be entered, place barricades or string yellow caution tape to designate the unsafe area. In some situations, the UNSAFE placard may also be used. See Table 2-4 for guidance on how to barricade an area.

5. Examples of typical posting and barricading situations are given in Table 2-5. Barricades can be required for any posting situation, even for buildings posted Inspected.

Table 2-3. Typical Restrictions Placed on Building Use

"Brief entry allowed to retrieve possessions only."
"Entry permitted to secure and repair structure."
"No public entry to building."
"Do not enter or use the following areas (specify)."
"Do not use the following exits: (specify)."
"Do not use fireplace."

Table 2-4. Guidelines for Barricading

1. Use caution tape or cones only initially. Chain link fences and wood or metal barricades make better long-term restraints.
2. Do not set barricades too close. Glass and brick walls can shatter on impact. Initially set the barricades wide. After a Detailed Evaluation or a period of stability (e.g., several days or a week or more), they often can be moved closer to the building.
3. When a downtown area (e.g., several city blocks) has extensive damage, recommend temporarily cordoning off the entire area. This avoids the need to barricade individual buildings and helps prevent theft.
4. Recommend the posting of guards at structures in imminent danger of collapse.
5. Recommend scaffolding and planking be installed over sidewalks and entrances to protect pedestrians when falling hazards are relatively small (e.g., a few bricks).
6. If safe to do so, try to keep one lane open for traffic when barricading street and sidewalk areas.

Essential Facilities

Essential facilities such as hospitals and police and fire stations should be given Detailed Evaluations by structural engineers as soon as possible. Refer to Chapter 13 for further information.

Aftershocks

Significant aftershocks ordinarily require reinspection of buildings posted Inspected or Restricted Use and may even require reinspection of buildings posted Unsafe if further damage can threaten adjacent structures. Whenever a building is reinspected, a new placard should be posted to indicate the date and time of reinspection, even if the posting classification is unchanged.

Table 2-5. Examples of Posting and Barricading

Condition Present	Action
Buildings	
• Building in danger of collapse.	Post building Unsafe and barricade.
• Building in danger from collapse of adjacent structure.	Post building Unsafe and barricade.
• Building in danger from slope failure.	Post building Unsafe and barricade.
• Building structurally safe, but its use or entry are prevented by another hazard (e.g., ruptured gas line, toxic chemical spill).	Post building Unsafe or Restricted Use.
• Building appears to be of doubtful safety; Detailed Evaluation is recommended.	Post building Restricted Use with only brief entry permitted.
• One room is unsafe, but the remainder of the building is usable.	Post building Restricted Use with no use of unsafe room.
• Dwelling is undamaged, but chimney has fallen away.	Post dwelling Restricted Use with no use of fireplace permitted.
• Building has little damage, but back stairs are dangerous.	Post building Restricted Use with no use of damaged exit permitted. Barricade back stairs.
• Building has minor damage that does not create a hazard for occupancy.	Post building Inspected.

Table 2-5. Examples of Posting and Barricading (Continued)

Condition Present	Action
Equipment	
• Elevators have been damaged.	Barricade elevator doors and switches. (If caution tape is unavailable, UNSAFE placards may also be used by placing them on elevator doors or switches.)
Falling or Other Hazards	
• Building has falling hazard present (e.g., damaged parapet, cracked window).	Barricade danger zone and/or post Restricted Use or Unsafe. (Placards may be placed on a perimeter barricade for this purpose.)
• Ruptured gas line, toxic chemical spill.	Barricade danger zone. Post building(s) Restricted Use with no use of endangered areas.
• Fallen power lines.	Barricade danger zone. Post buildings Restricted Use with no use of endangered areas.

Locked Buildings

Some buildings such as tilt-up structures (see Chapter 7) will require entry to complete the evaluation. If a building is locked and no one is around, do not post the building if the evaluation cannot be completed by only an exterior evaluation. Instead, notify the local jurisdiction that the building needs to be examined from the interior before the safety evaluation can be completed.

Retrieval of Possessions and Salvage

If a building is no longer habitable, occupants may need to retrieve merchandise, business records, and personal belongings. Retrieval of possessions is permitted for buildings posted Inspected and Restricted Use, if retrieval can be accomplished in accordance with the restrictions. In buildings posted Unsafe, retrieval of possessions and salvage is only permitted when approved by the local building department. Appendix D provides guidelines for entry into damaged buildings.

Changing a Posting

There may be a need to change the posting of a building. This can result from several situations including:

- A Detailed Evaluation following an initial Rapid Evaluation,
- An Engineering Evaluation,
- Reinspection to verify or correct an existing posting,
- Reinspection after an aftershock,
- Reinspection after temporary repairs have been made, or
- Reinspection after removal of finishes to expose concealed conditions.

Any change in posting category (i.e., reposting) must be done only by an authorized representative of the local building department.

Use of Judgment Required

The use of *judgment* is essential in the evaluation of damaged buildings. Not every dangerous situation that may be encountered is covered by the guidelines and procedures given here. ***For those situations where no guidance has been provided, or if the guidance furnished is not appropriate for the situation, the inspecting teams must rely on their collective experience and judgment.*** When necessary, obtain additional help or request a Detailed or Engineering Evaluation.

3. Rapid Evaluation Method

Rapid Evaluation Criteria

The objective of Rapid Evaluation is to quickly inspect and evaluate buildings in the damaged area. It is performed by evaluating a building relative to six basic criteria, which are listed in Table 3-1. These criteria are primarily externally observable conditions that, individually or collectively, are sufficient to warrant use of the Unsafe posting or barricading of an unsafe area.

If a building is found to have none of the conditions listed in Table 3-1, and if there are no other hazards or unsafe conditions present, it is apparently safe and can be posted Inspected.

In doubtful situations, the use of judgment is required. Buildings with moderate damage can be difficult to evaluate, especially during a Rapid Evaluation. When there is uncertainty about posting a structure Unsafe, consider posting it Restricted Use (with appropriate restrictions indicated) and request a Detailed Evaluation.

Examples of conditions that illustrate each of the six Rapid Evaluation criteria are shown in Figure 3-1.

Inspection Procedure

Because the Rapid Evaluation method is designed to quickly find serious damage and to conserve limited personnel resources in the immediate postevent period, the safety evaluations are generally limited and brief. Inspectors are to look for readily observable, gross kinds of structural damage and distress, hazardous geotechnical conditions (e.g., landsliding), and other hazards that threaten building safety. The step-by-step inspection procedure is summarized in Table 3-2 .

Table 3-1. Rapid Evaluation Criteria

Condition	Action[a]
1. Building has collapsed, partially collapsed, or moved off its foundation.	Post Unsafe.
2. Building or any story is significantly out of plumb (i.e., leaning).	Post Unsafe.
3. Obvious severe damage to primary structural members, severe racking of walls, or other signs of severe damage and distress present.	Post Unsafe.
4. Obvious parapet, chimney, or other falling hazard present.	Post Restricted Use and barricade the unsafe area.
5. Large fissures in ground, massive ground movement, or slope displacement is present.	Post Unsafe.
6. Other hazard present (e.g., toxic spill, asbestos contamination, broken gas line, fallen power line).	Post Unsafe and/or barricade unsafe area[b]

a. In completing the Rapid Evaluation assessment form, the evaluating team will be asked to determine the degree of damage (minor/none, moderate, or severe) and to determine the posting. The posting or action recommended above is for the severe situation.

b. Restricted Use posting may be applicable in certain situations.

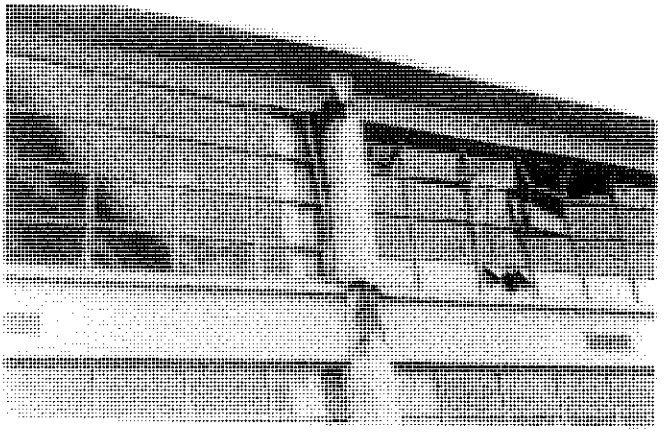
Conservative vs. Unconservative Safety Evaluations

It is important that posting decisions be carefully considered, particularly those that will displace individuals and businesses. Unnecessarily conservative postings must be avoided. On the other hand, individuals must not be exposed to unnecessary risk. When in doubt, request a Detailed Evaluation.

Condition 1: Collapse, partial collapse, or moved off foundation. Post Unsafe.

Condition 2: Building or story out of plumb. Post Unsafe.

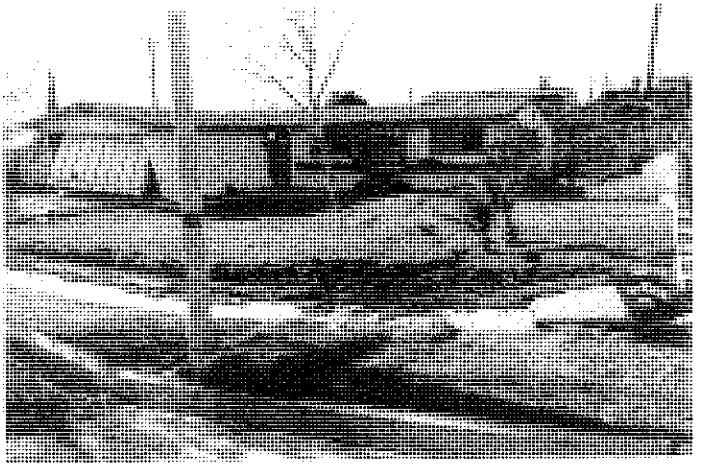
Figure 3-1 Examples of "Unsafe" buildings or situations using Rapid Evaluation criteria.



Condition 3: Obvious severe damage to primary structural members, severe racking of walls, or other severe damage and distress. Post Unsafe.

Condition 4: Obvious parapet or other falling hazard. Post Restricted Use and barricade the unsafe area.

Figure 3-1 Examples of "Unsafe" buildings or situations using Rapid Evaluation criteria. (Continued)



Condition 5: Building damaged by severe ground displacement or foundation damage. Post Unsafe.

Condition 6: Other hazard present (e.g., overturned LPG tank). Barricade unsafe area.

Figure 3-1 Examples of "Unsafe" buildings or situations using Rapid Evaluation criteria. (Continued)

Table 3-2. Rapid Evaluation Inspection Procedure

1. Examine the entire outside of the structure.
2. Examine the ground and pavement in the general area of the structure for fissures, bulged ground, or signs of slope movement.
3. Enter a building when the structure cannot be viewed sufficiently from the outside and when there is a suspected or reported problem such as nonstructural distress (e.g., fallen ceiling or damaged partitions). See "Guidance on Entering a Building" (below). ***Do not enter obviously unsafe structures.***
4. Evaluate the structure using the six criteria (Table 3-1). Complete the Rapid Evaluation form (Figure 3-2). Make sure that exitways are clear and usable. Doubtful buildings should be slated for a Detailed Evaluation. Record any restrictions placed on use of the structure on the Rapid Evaluation form.
5. Post the structure according to the results of the evaluation. Use one of the three placards INSPECTED, RESTRICTED USE, or UNSAFE). Indicate on the placard whether the inspection included only the "exterior" or the "exterior and interior" by checking the appropriate box. Post every entrance to a building classified as Restricted Use or Unsafe (except single-family dwellings).
6. Explain the significance of Restricted Use or Unsafe postings to building occupants, if they are available. Advise them to leave unsafe buildings immediately, but do not create panic. Unsafe areas must also be evacuated.

Guidance on Entering a Building

Most Rapid Evaluations are primarily exterior inspections, but there are situations in which inspectors should try to enter a building:

- when interior damage is suspected,
- when interior damage is visible from the outside,
- when not enough of the structure can be seen from the outside, and
- to talk with the manager or occupants of large buildings.

When done as part of Rapid Evaluation, interior inspections are typically of short duration and limited scope. Unless authorized by the local jurisdiction, buildings should not be entered without the permission of the owner or occupant. ***Do not enter obviously unsafe buildings.*** Entry into damaged buildings should be done according to the guidelines in Appendix D.

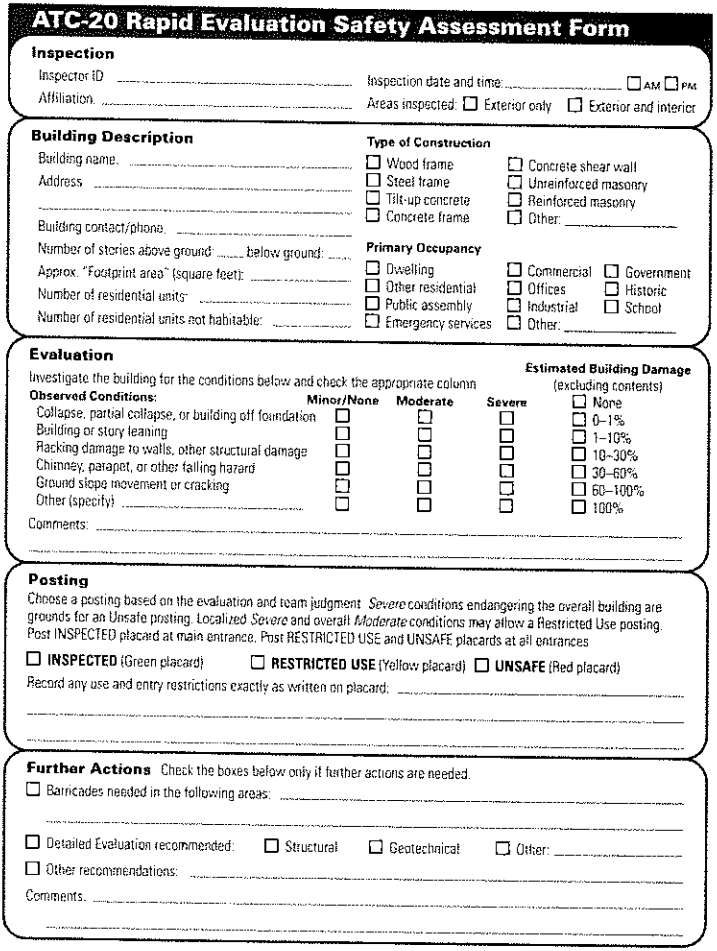
Filling out Placards and Assessment Forms

Here are some things to remember when filling out placards and Rapid Evaluation Assessment forms (Figure 3-2):

1. Follow the directions of the local jurisdiction. Fill out all of the placard and assessment form that you are asked to complete.
2. Restrictions placed on a RESTRICTED USE placard must be repeated word-for-word on the Rapid Evaluation Assessment form.
3. Forms must be neatly and accurately completed. Printing is recommended for legibility.
4. Make sure the address is correct. For example, 234 10th Street is not the same as 234 10th Avenue.
5. Completed forms are turned into the local jurisdiction.

Estimates of Damage

The Rapid Evaluation form has a place to iudicate estimated percentage damage. Normally, damage estimation is optional and is not done as part of a safety evaluation, unless specifically requested by the local building department. In any event, the placard posted on a building is not an indication of the amount of monetary loss or the damage as a percentage of the replacement cost, but simply an indication of its safety status.



ATC-20 Rapid Evaluation Safety Assessment Form

Inspection

Inspector ID _____ Inspection date and time: _____ ☐ AM ☐ PM

Affiliation _____ Areas inspected: ☐ Exterior only ☐ Exterior and interior

Building Description

Building name: _____

Address: _____

_____

Building contact/phone: _____

Number of stories above ground: _____ below ground: _____

Approx. "Footprint area" (square feet): _____

Number of residential units: _____

Number of residential units not habitable: _____

Type of Construction

☐ Wood frame ☐ Concrete shear wall

☐ Steel frame ☐ Unreinforced masonry

☐ Tilt-up concrete ☐ Reinforced masonry

☐ Concrete frame ☐ Other: _____

Primary Occupancy

☐ Dwelling ☐ Commercial ☐ Government

☐ Other residential ☐ Offices ☐ Historic

☐ Public assembly ☐ Industrial ☐ School

☐ Emergency services ☐ Other: _____

Evaluation

Investigate the building for the conditions below and check the appropriate column

Observed Conditions:	Minor/None	Moderate	Severe	Estimated Building Damage (excluding contents)
Collapse, partial collapse, or building off foundation	☐	☐	☐	☐ None
Building or story leaning	☐	☐	☐	☐ 0–1%
Racking damage to walls, other structural damage	☐	☐	☐	☐ 1–10%
Chimney, parapet, or other falling hazard	☐	☐	☐	☐ 10–30%
Ground slope movement or cracking	☐	☐	☐	☐ 30–60%
Other (specify) _____	☐	☐	☐	☐ 60–100%
				☐ 100%

Comments: _____

_____

Posting

Choose a posting based on the evaluation and team judgment. *Severe* conditions endangering the overall building are grounds for an Unsafe posting. Localized *Severe* and overall *Moderate* conditions may allow a Restricted Use posting. Post INSPECTED placard at main entrance. Post RESTRICTED USE and UNSAFE placards at all entrances.

☐ **INSPECTED** (Green placard) ☐ **RESTRICTED USE** (Yellow placard) ☐ **UNSAFE** (Red placard)

Record any use and entry restrictions exactly as written on placard: _____

_____

_____

Further Actions Check the boxes below only if further actions are needed.

☐ Barricades needed in the following areas: _____

_____

☐ Detailed Evaluation recommended: ☐ Structural ☐ Geotechnical ☐ Other: _____

☐ Other recommendations: _____

Comments: _____

_____

Figure 3-2 Rapid Evaluation Assessment Form. This form may be downloaded at ***www.atcouncil.org***.

4. Detailed Evaluation Method

A Detailed Evaluation is primarily used to determine the safety of doubtful buildings following an initial Rapid Evaluation. Typically, these are buildings posted Restricted Use or Unsafe pending a more thorough examination. The method, which relies on visual observations by structural engineers, is intended to provide reasonable assurance that a building, although damaged, is sufficiently safe to use, or alternately that part or all of the building must be closed because of safety concerns. Detailed Evaluation is also used to evaluate essential facilities, *in lieu* of Rapid Evaluation, whenever damage is suspected.

Ideally, a Detailed Evaluation will be carried out by a team of at least two structural engineers. In the aftermath of a large earthquake, however, this may not always be possible. One alternative is the use of a team consisting of a structural engineer and a building inspector.

Detailed Evaluation Criteria

The following chapters provide guidance on making Detailed Evaluations of various construction types, geotechnical hazards, and nonstructural elements.

Item or Building Type	*Chapter*
Wood-Frame Structures	5
Masonry Structures	6
Tilt-up Structures	7
Concrete Structures	8
Steel-Frame Structures	9
Mobile Homes	10
Geotechnical Hazards	11
Nonstructural Hazards	12

After identifying the building type or item to be inspected, review the corresponding chapter for guidance on completing the evaluation and determining the posting. The chapters list specific safety concerns for each building type or item and give advice on rating the safety significance of specific conditions (e.g., a badly cracked unreinforced masonry building is to be posted Unsafe). For most of the conditions listed, the recommended posting is Unsafe; however, the condition observed must be sufficiently hazardous that it requires the ***entire*** building to be posted Unsafe. If not, post the building Restricted Use, and restrict entry into unsafe areas. Avoid imposing unwarranted hardship on owners and occupants of damaged buildings, but avoid exposing occupants and the public to unnecessary risk.

Posting Criteria for Detailed Evaluations

A brief general description of building condition corresponding to each of the three posting categories (Inspected, Restricted Use, and Unsafe) is given in Table 2-2 on page 6. The following criteria are more detailed and should be used in conjunction with a Detailed Evaluation:

Inspected. To post a structure Inspected, which indicates that there are no restrictions on use or occupancy, ***all*** of the following conditions must be satisfied:

1. The structural system has not been significantly damaged (i.e., both vertical- and lateral-load systems are intact and without significant damage).
2. No falling or other hazards are present.
3. No evidence of significant foundation damage or ground displacement is present.
4. Main exits are operable and accessible.
5. No other apparent unsafe condition exists.

Restricted Use. To post a structure Restricted Use, which indicates that entry and use have been restricted, *one* of the following conditions must be present:

1. A structural or other hazard requires that a *part* or *parts* of the structure not be entered or used.
2. Uncertainty about the building's safety that can only be resolved by further evaluation (e.g., an Engineering Evaluation).

Unsafe. To post a structure Unsafe, which indicates that it is unsafe for occupancy or entry[1], *one* of the following conditions must be present:

1. Obvious safety hazards (e.g., leaning building, partially collapsed building) require that the *entire* building not be entered or occupied.
2. Degree of damage is such that it is unsafe to enter or occupy the *entire* building.
3. Another unsafe condition (e.g., known toxic material release, landslide threat) requires that the *entire* building not be entered or occupied.

Detailed Evaluation Procedure

A Detailed Evaluation is a thorough visual examination of a damaged building, inside and out. It consists of a number of steps, as summarized below.

STEP 1: *Survey the Building from the Outside*

a. Try to determine the structural system.

1. Entry into structures posted Unsafe is not permitted without the permission of the local building department. See Appendix D for further information.

b. Examine the structure for damage on all accessible sides, particularly at vertical discontinuities (Figure 4-1) and at irregular configurations in plan (Figure 4-2).

c. Look for racking of walls, broken glass, concrete spalling, or other signs of damage.

d. Examine nonstructural elements such as cladding, parapets, signs, and ornamentation for damage.

e. Look for fractures in the foundation or exposed lower walls of the building.

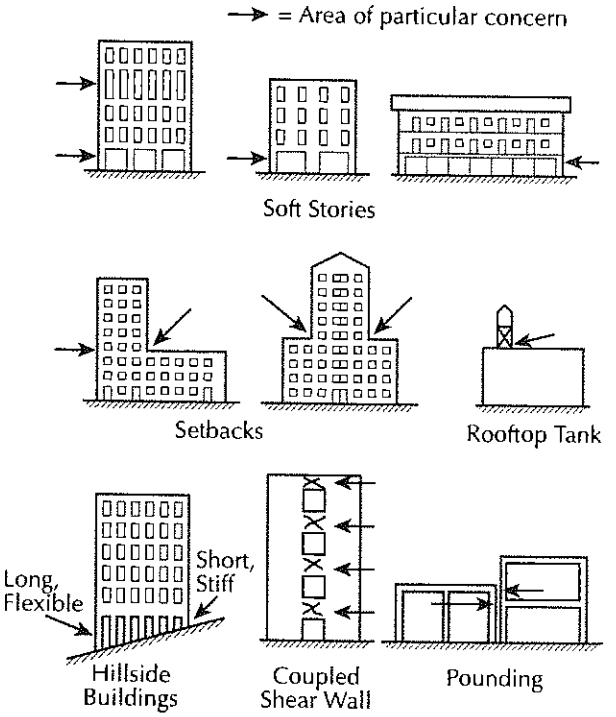


Figure 4-1 Structural systems with vertical discontinuities or irregularities.

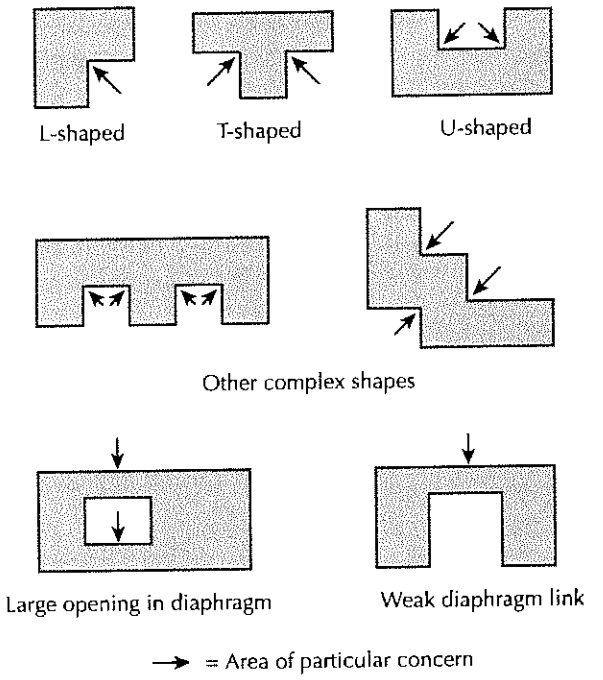


Figure 4-2 Buildings with irregular configurations in plan.

STEP 2: *Examine the Site for Geotechnical Hazards*

a. Be aware that geotechnical hazards can extend over an area of several buildings or more.

b. Look for fissures, bulged ground, and vertical ground movements in the area.

c. In hillside areas, examine tbe area for landslide displacement or debris encroaching onto the site.

d. When geotechnical hazards are suspected, a Detailed Evaluation should be made by a team including a geotechnical engineer or geologist.

STEP 3: *Inspect the Structural System from Inside the Building*

a. Before entering the building, look for falling or collapse hazards. Do not enter obviously unsafe buildings.

b. Ceiling panels may be removed to view the structural system, but any destructive exploration must be arranged by the owner (see "When the Structural System is not Viewable" on page 26).

c. Look in stairwells, basements, mechanical rooms, and other exposed areas as required to view the structural system.

d. Examine the vertical-load-carrying system. Look for situations in which a column may show signs of failure, where the floor or roof framing has begun to pull away from its vertical supports, or where the slab or beam system has failed or begun to fail.

e. Examine the lateral-load-carrying system. Any residual story drift means that some structural damage has been sustained.

f. Inspect the basement for fractures and uneven settlement. Also inspect basement floors and exterior walls for cracks and bulges.

g. Examine every floor, including the basement, roof, and penthouse.

STEP 4: *Inspect for Nonstructural Hazards*

a. Inside the building, look for damage to nonstructural elements such as ceilings, partitions, light fixtures, roof-top tanks, and other appendages. If cladding damage suspected, inspect representative connections. See Chapter 12 for further guidance.

STEP 5: *Inspect for Other Hazards*

a. If damage is present or suspected that would affect the safe operation of elevators, the elevators should not be restarted without inspection by a qualified person.

b. Look for spills or leaks in areas of stored chemicals or other hazardous materials.

c. If damage to fire protection and detection equipment is observed, it may be necessary to restrict building use. Notify the local jurisdiction.

d. Inspect stairs for structural stability and exits for jammed doors and obstructions.

STEP 6: *Complete Checklist and Post Building*

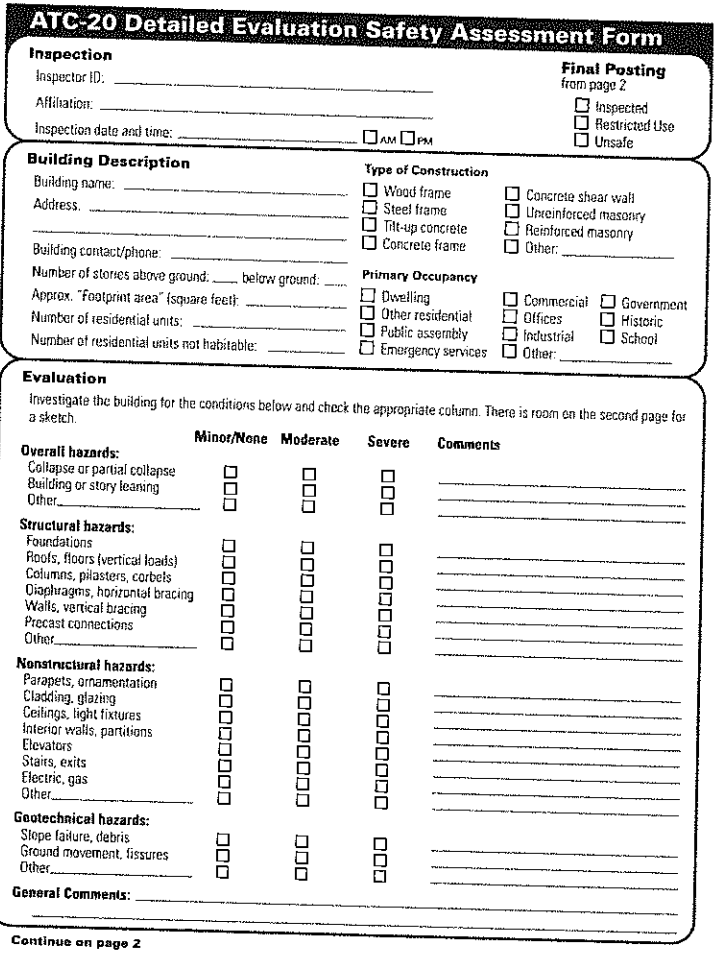
a. Evaluate the structure and complete the Detailed Evaluation Form (Figures 4-3 and 4-4). Indicate if shoring or bracing or other action is needed.

b. Post the structure according to the results of the evaluation. Use one of the three placards (INSPECTED, RESTRICTED USE, or UNSAFE). Except for single-family dwellings, post every entrance to a building classified as Restricted Use or Unsafe. Post the front entrance of single-family residences.

c. Explain the significance of Restricted Use and Unsafe postings to occupants, and advise them to leave unsafe areas immediately.

When the Structural System is not Viewable

Architectural finishes such as walls and ceilings conceal the structural system of most buildings. When serious damage is suspected and not enough of the structural system is viewable to permit a reliable evaluation, post the building Restricted Use or Unsafe and advise the occupants of the significance of the posting. Table 2-3 provides examples of typical restrictions for buildings posted Restricted Use. If possible, inform the owner that he or she must either arrange for demolition or removal of walls, plaster ceilings, and other architectural finishes to permit completion of the Detailed Evaluation, or alternately arrange for an Engineering Evaluation.



ATC-20 Detailed Evaluation Safety Assessment Form

Inspection

Inspector ID: _____

Affiliation: _____

Inspection date and time: _____ ☐ AM ☐ PM

Final Posting from page 2

☐ Inspected
☐ Restricted Use
☐ Unsafe

Building Description

Building name: _____

Address: _____

_____

Building contact/phone: _____

Number of stories above ground: ____ below ground: ____

Approx. "Footprint area" (square feet): _____

Number of residential units: _____

Number of residential units not habitable: _____

Type of Construction

☐ Wood frame
☐ Steel frame
☐ Tilt-up concrete
☐ Concrete frame
☐ Concrete shear wall
☐ Unreinforced masonry
☐ Reinforced masonry
☐ Other: _____

Primary Occupancy

☐ Dwelling
☐ Other residential
☐ Public assembly
☐ Emergency services
☐ Commercial
☐ Offices
☐ Industrial
☐ Other: _____
☐ Government
☐ Historic
☐ School

Evaluation

Investigate the building for the conditions below and check the appropriate column. There is room on the second page for a sketch.

	Minor/None	Moderate	Severe	Comments
Overall hazards:				
Collapse or partial collapse	☐	☐	☐	
Building or story leaning	☐	☐	☐	
Other_____	☐	☐	☐	
Structural hazards:				
Foundations	☐	☐	☐	
Roofs, floors (vertical loads)	☐	☐	☐	
Columns, pilasters, corbels	☐	☐	☐	
Diaphragms, horizontal bracing	☐	☐	☐	
Walls, vertical bracing	☐	☐	☐	
Precast connections	☐	☐	☐	
Other_____	☐	☐	☐	
Nonstructural hazards:				
Parapets, ornamentation	☐	☐	☐	
Cladding, glazing	☐	☐	☐	
Ceilings, light fixtures	☐	☐	☐	
Interior walls, partitions	☐	☐	☐	
Elevators	☐	☐	☐	
Stairs, exits	☐	☐	☐	
Electric, gas	☐	☐	☐	
Other_____	☐	☐	☐	
Geotechnical hazards:				
Slope failure, debris	☐	☐	☐	
Ground movement, fissures	☐	☐	☐	
Other_____	☐	☐	☐	

General Comments: _____

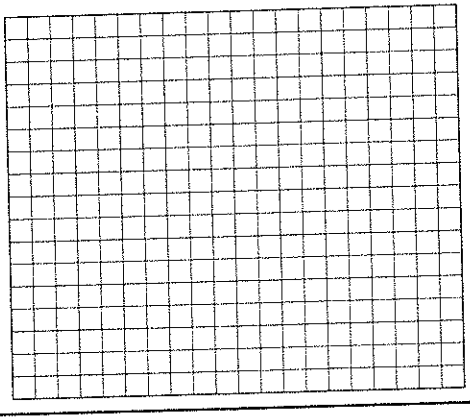
Continue on page 2

Figure 4-3 Detailed Evaluation Safety Assessment Form (page 1). This form may be downloaded at ***www.atcouncil.org***.

ATC-20 Detailed Evaluation Safety Assessment Form **Page 2**

Building name: _____ Inspector ID: _____

Sketch (optional)
Provide a sketch of the building or damaged portions. Indicate damage points.



Estimated Building Damage
If requested by the jurisdiction, estimate building damage (repair cost ÷ replacement cost, excluding contents).

- ☐ None
- ☐ 0–1%
- ☐ 1–10%
- ☐ 10–30%
- ☐ 30–60%
- ☐ 60–100%
- ☐ 100%

Posting
If there is an existing posting from a previous evaluation, check the appropriate box.
Previous posting: ☐ INSPECTED ☐ RESTRICTED USE ☐ UNSAFE Inspector ID: _____ Date: _____

If necessary, revise the posting based on the new evaluation and team judgment. *Severe* conditions endangering the overall building are grounds for an Unsafe posting. Local *Severe* and overall *Moderate* conditions may allow a Restricted Use posting. Indicate the current posting below and at the top of page one.

☐ **INSPECTED** (Green placard) ☐ **RESTRICTED USE** (Yellow placard) ☐ **UNSAFE** (Red placard)

Record any use and entry restrictions exactly as written on placard: _____

Further Actions Check the boxes below only if further actions are needed.

☐ Barricades needed in the following areas: _____

☐ Engineering Evaluation recommended: ☐ Structural ☐ Geotechnical ☐ Other: _____

☐ Other recommendations: _____

Comments: _____

Figure 4-4 Detailed Evaluation Safety Assessment Form (page 2).

Estimates of Damage

The Detailed Evaluation form has a place to indicate estimated percentage damage. Normally, damage estimation is optional and is not done as part of a safety evaluation, unless specifically requested by the local building department. In any event, the placard posted on a building is not an indication of the amount of monetary loss or the damage as a percentage of the replacement cost, but simply an indication of its safety status.

5. Inspection and Posting of Wood-Frame Structures

Dwellings and Small Buildings

Well-designed wood-frame dwellings and small buildings have generally had a good earthquake performance record. Dwelling failures that have occurred (see Figure 5-1) have often been due to lack of foundation anchorage or weak cripple walls. Chimneys in older homes are frequently damaged and may become falling or fire haz-

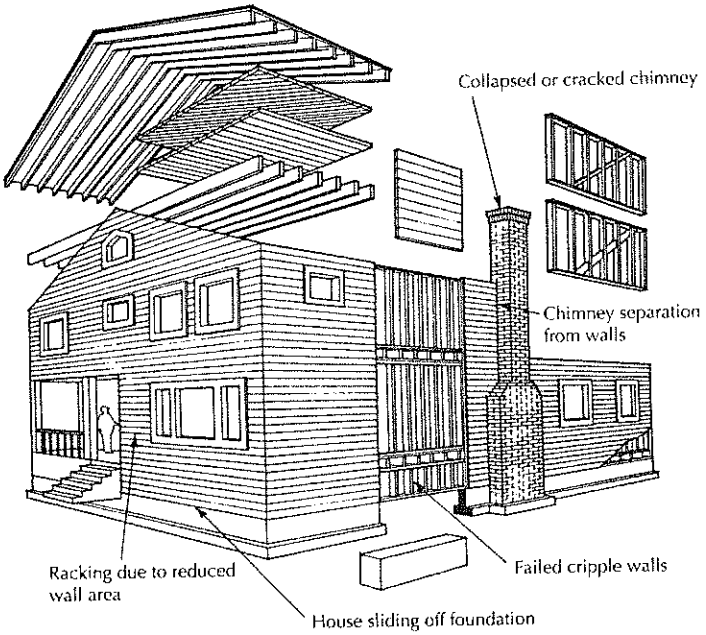


Figure 5-1 Inspection points for older wood-frame dwellings.

ards. Hillside and split-level homes may experience damage attributable to irregular framing and eccentricities.

Inspect the building to determine if any of the principal safety concerns listed below exist. Inspection points for an older wood-frame building are shown in Figure 5-1. There may also be other hazards. For many of the conditions listed, the recommended posting is Unsafe; however, the conditions must be sufficiently hazardous that they endanger the overall building and require the *entire* structure to be posted Unsafe. If conditions are locally severe but overall moderate, a Restricted Use posting may be appropriate. In this situation, restrictions may be placed on entry into unsafe areas, or entry restricted to only essential personnel and repair workers.

Condition	Posting
1. Overall Damage	
Collapse or partial collapse	Unsafe
Separation between two parts of building (Figure 5-2)	Unsafe
2. Roof/Floors	
Roof or floor displaced from walls	Unsafe
Canopy, porch or sunscreen separation from main structure	Restricted Use[1]
Chimney falling hazard	Restricted Use[1]
Tile roof falling hazard	Restricted Use[1]
3. Walls/Bracing	
Building or individual story leaning one to two inches or more per story (Figure 5-2)	Unsafe
Cripple wall failure (Figures 5-3 and 5-4)	Unsafe

1. Barricade unsafe areas.

Hillside homes with broken bracing, posts with residual lean, or post or pier displacement ..... Unsafe

4. Foundations

Building off foundation (Figure 5-5) ..... Unsafe

Signs of movement at foundation level ..... Restricted Use

Severely fractured foundations ..... Unsafe

5. Other Hazards

Gas leak ..... Restricted Use

Overturned gas water heater ..... Restricted Use

Falling hazard present (See Chapter 12) ..... Restricted Use[1]

Figure 5-2 There is residual lean in the garage opening and separation between portions of the structure. Post Unsafe.

1. Barricade unsafe areas.

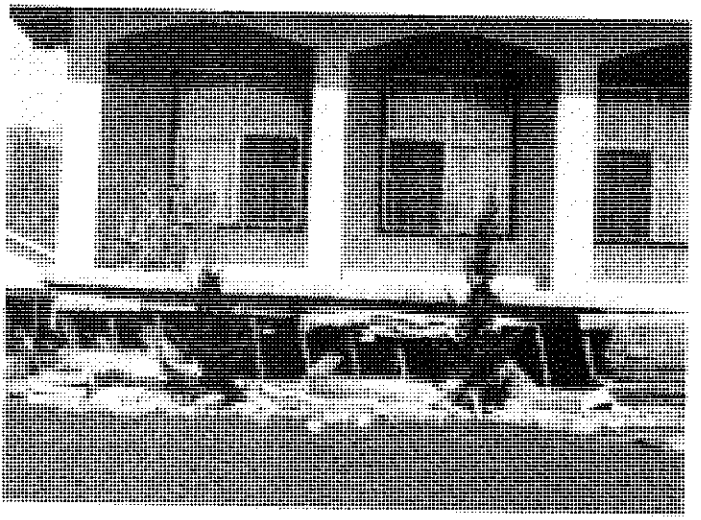


Figure 5-3 Home leaning to the left with damaged cripple walls. Post Unsafe.

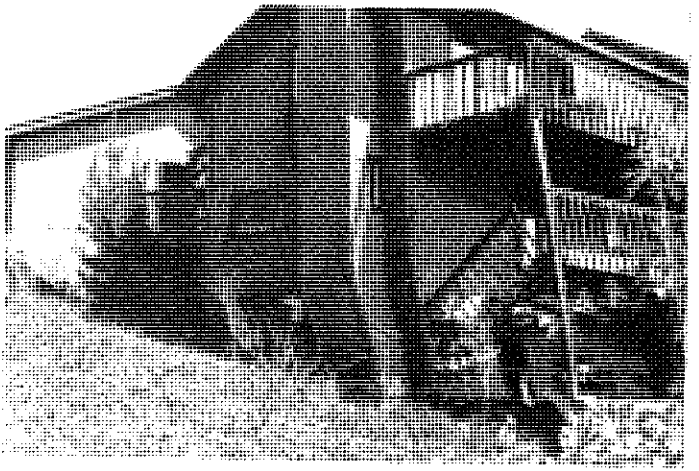


Figure 5-4 Hillside home with tall cripple walls that have failed. Post Unsafe.

Figure 5-5 House has moved off its foundation. Post Unsafe.

Large Wood-Frame Structures

Large wood-frame structures can include apartments, commercial buildings, and warehouses. Damage may result from such things as weak roof-to-wall ties, poor configuration of lateral-force-resisting elements, and weak shear walls or diaphragms. Connections between elements must be carefully inspected. Because of the great diversity in these structures, it is very important for the damage inspector to try to determine the structural system and then inspect it.

Inspect the building to determine of any of the principal safety concerns listed below exist. There may also be other hazards. For most of the conditions listed, the recommended posting is Unsafe; however, the conditions must be sufficiently hazardous that they endanger the overall building and require the *entire* structure to be posted Unsafe. If conditions are locally severe but overall moderate, a Restricted Use posting may be appropriate. In this situation, restrictions may be placed on entry into unsafe areas, or entry restricted to only essential personnel and repair workers.

Condition	Posting
1. Overall Damage	
Collapse or Partial Collapse	Unsafe
Building or individual story noticeably leaning (Figures 5-6 and 5-7)	Unsafe
2. Roof/Floors	
Failed member or connections in roof truss	Unsafe
Roof or floor framing separation from vertical support	Unsafe
Other failure or incipient failure of significant vertical-load-carrying element or connection	Unsafe
3. Columns	
Columns noticeably out of plumb	Unsafe
Buckled or failed columns	Unsafe
4. Wood Walls	
Failed shear walls	Restricted Use or Unsafe
Residual in-plane wall racking of one to two inches or more per story (10 feet) in shear wall	Unsafe
Failure or imminent failure of wall providing vertical support	Unsafe
5. Diaphragms, Horizontal Bracing	
Bowed, broken or seriously damaged diaphragm	Restricted Use or Unsafe
Broken or severely damaged chord or collector	Restricted Use or Unsafe
Movement or failure at shear connection between diaphragm and wall	Restricted Use or Unsafe
Broken horizontal bracing	Restricted Use or Unsafe

6. Foundations

Building off its foundation. . . . . Unsafe.

Building showing signs of beginning to move off its foundation . . . . . Restricted Use

Severely fractured foundation. . . . . Unsafe

7. Other

Falling hazard present (see Chapter 12). . . . . Restricted Use[1]

Gas leak. . . . . Restricted Use

Figure 5-6 Open-front apartment with severe damage. Post Unsafe.

1. Barricade unsafe areas.

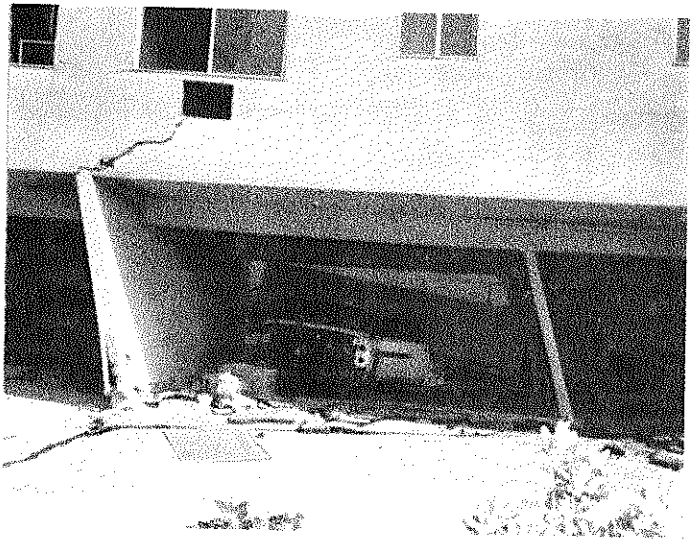


Figure 5-7 Another view of the apartment building in Figure 5-6, showing severe lean.

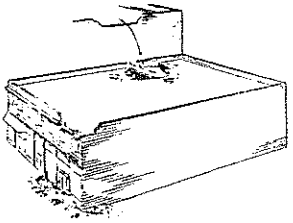
6. Inspection and Posting of Masonry Structures

There are two kinds of masonry construction: unreinforced and reinforced. Unreinforced masonry (URM) structures, particularly bearing-wall structures, are one of the most hazardous forms of construction found in the United States. Many URM buildings have been retrofitted (e.g., parapets braced, wall-roof ties added), and this can reduce the general level of damage experienced. Reinforced masonry structures have performed much better; however, some reinforced masonry structures have construction similar to tilt-up buildings (see Chapter 7), and wall-roof and wall-floor separations can occur.

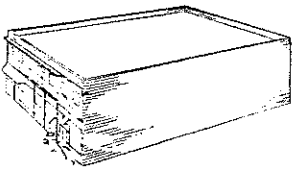
Many, if not most, unreinforced masonry structures, including adobe construction, have wood floors and roofs. Floors and walls are often not tied together for horizontal earthquake forces or, when tied together, they are only weakly connected. Due to their age, these structures may also have deteriorated mortar. Additionally, individual wythes of walls, particularly those without headers (bricks laid with the butt end on the exterior face of the wall), may not be connected except by mortar in tension, making the walls particularly prone to out-of-plane failures. Some walls may be covered by plaster or other materials, making identification more difficult.Various forms of damage to URM buildings are shown in Figure 6-1.

See Figure 6-2 for inspection points of unreinforced masonry bearing-wall buildings. (Note that concrete and steel-frame buildings with infill masonry walls are covered in Chapters 8 and 9, respectively.)

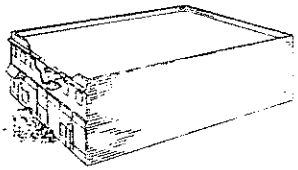
Inspect the building to determine if any of the principal safety concerns listed below exist. There may also be other hazards. For most



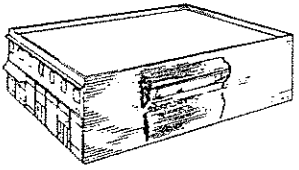
Parapet failure



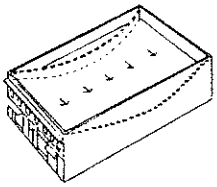
Nonparapet falling hazards



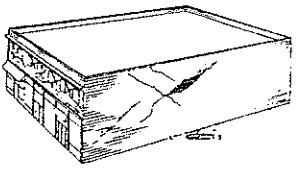
Wall-diaphragm tie failure



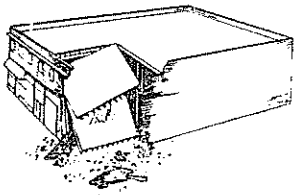
Wall failure in bending between diaphragms



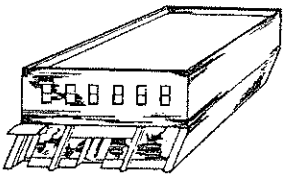
Excessive diaphragm deflection



Inplane wall failure



Roof and/or floor collapse



Soft story or other configuration-induced failure

Figure 6-1 Examples of various forms of earthquake damage to URM buildings.

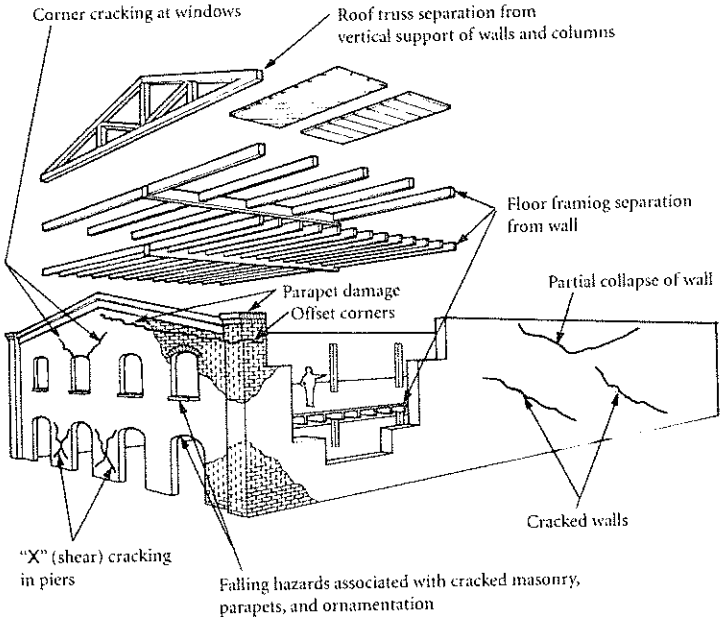


Figure 6-2 Inspection points for low-rise unreinforced masonry bearing-wall buildings.

of the conditions listed, the recommended posting is Unsafe; however, the conditions must be sufficiently hazardous that they endanger the overall building and require the *entire* structure to be posted Unsafe. If conditions are locally severe but overall moderate, a Restricted Use posting may be appropriate. In this situation, restrictions may be placed on entry into unsafe areas, or entry restricted to only essential personnel and repair workers.

Condition	Posting
1. Overall Damage	
Collapse or partial collapse	Unsafe
Building or individual story noticeably leaning	Unsafe

2. Roof and Floor Framing

Roof or floor framing separation from vertical supports (Figure 6-3) ..... Unsafe

Other failure or incipient failure of significant vertical load-carrying element or connection (Figure 6-4) ..... Unsafe

3. Columns

Columns noticeably out of plumb ..... Unsafe

Buckled or failed columns ..... Unsafe

4. Unreinforced Masonry Walls

Noticeably out of plumb ..... Unsafe

Diagonal, stepped (Figure 6-5), or other large cracking (Figure 6-6) ..... Unsafe

Wythe separation and masonry spalling ..... Restricted Use or Unsafe[1]

Wall or pilaster cracking or spalling that jeopardizes vertical support of roof or floor framing (Figure 6-4) .. Unsafe

Cracked parapet (Figure 6-6) ..... Restricted Use or Unsafe[1]

5. Reinforced Masonry Walls

Major walls with 1/8-inch or larger diagonal (shear) cracks ..... Restricted Use or Unsafe[1]

Several failed piers at any one story (Figure 8-14) ..... Unsafe

Walls with out-of-plane leaning ..... Unsafe

Wall or pilaster cracking or spalling that jeopardizes vertical support of roof or floor framing ..... Unsafe

Wall-roof separation ..... Unsafe

6. Diaphragms

Bowed, broken or seriously damaged diaphragm ..... Unsafe

1. Barricade unsafe areas.

Broken or seriously damaged chord or collector ..... Unsafe

Movement or failure at shear connection between diaphragm and masonry wall ..... Unsafe

7. Foundations

   Fractured foundation ..... Unsafe

8. Other

   Falling hazard present (see Chapter 12) ..... Restricted Use[1]

Engineering Evaluations of Masonry Wall Buildings

Seriously damaged masonry wall buildings, both reinforced and unreinforced, can be difficult to evaluate in a Detailed Evaluation and may require an Engineering Evaluation. FEMA 306, *Evaluation of Earthquake Damaged Concrete and Masonry Wall Buildings – Basic Procedures Manual* (ATC, 1998), provides guidelines for both the assessment of individual wall damage and the safety evaluation of the entire building.

1. Barricade unsafe areas.

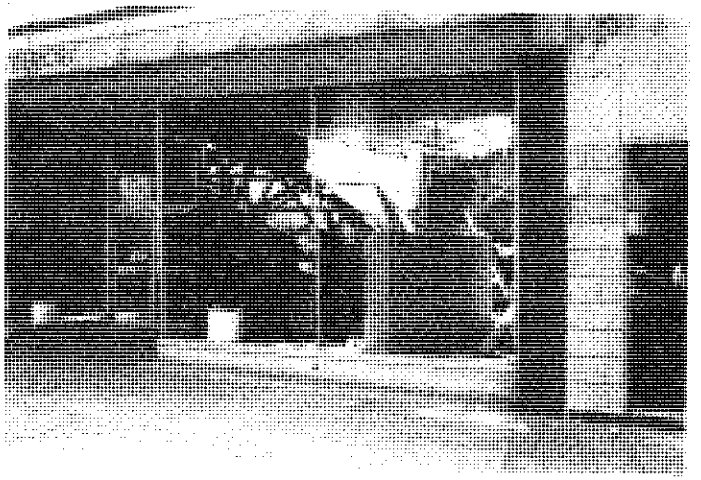


Figure 6-3 Collapse of a bowstring truss that was not well anchored to the masonry wall. The building was posted Unsafe.

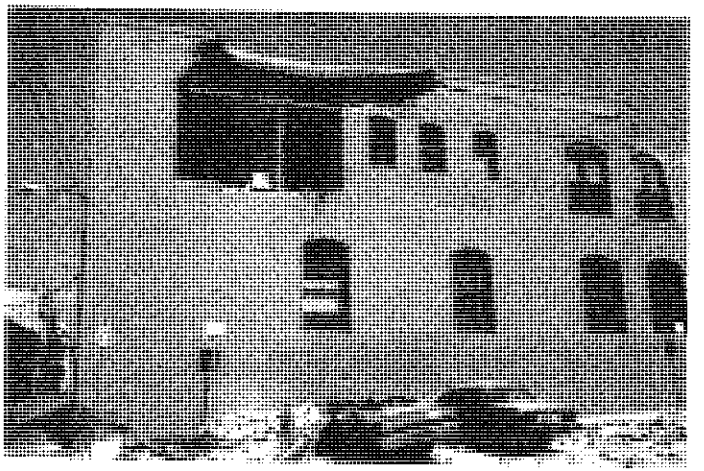


Figure 6-4 Out-of-plane wall damage to URM building. The top of the wall at the right is an imminent collapse hazard. The building was posted Unsafe and the parking lot barricaded.

Figure 6-5 Unreinforced masonry wall with a stepped crack.

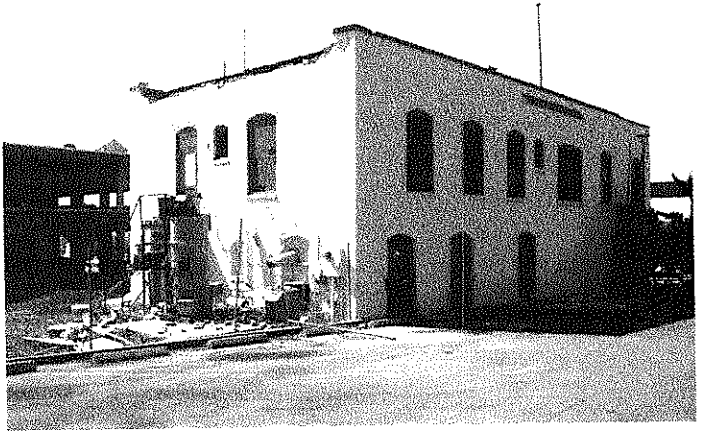


Figure 6-6 Damage to an unreinforced masonry building. In addition to the obvious parapet damage, walls in this building were badly cracked, and the building was posted Unsafe.

7. Inspection and Posting of Tilt-Up Structures

Tilt-up construction involves casting concrete walls at the site and tilting them into place. The earthquake problems associated with tilt-up construction can be quite significant. The most common failure mode has been wall-roof separation resulting from inadequate ties. Many tilt-up buildings constructed before the mid-1970s were constructed without positive ties between the roof and walls (Figure 7-1). During the 1994 Northridge earthquake, even very recent tilt-up buildings experienced severe wall-roof separations. These buildings had wall anchors, but the wall anchors were of insufficient strength. Other problems have included spalling at cor-

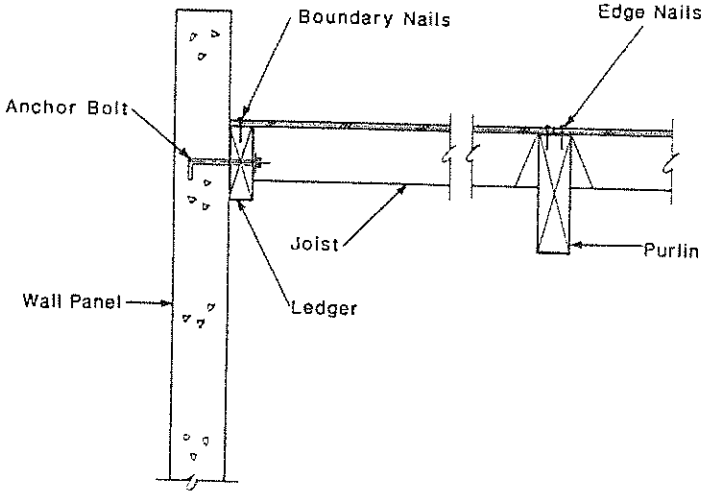


Figure 7-1 Inspect the diaphragm-to-wall tie for signs of separation. The type of wall-panel anchorage shown above is prone to failure through cross-grain bending in the ledger or through nail pull.

bels or at tops of pilasters, failure of diaphragm collectors, diaphragm failures in the interior of the roof, and failure or excessive cracking in panels with large openings. Figure 7-2 indicates inspection points for a typical tilt-up building.

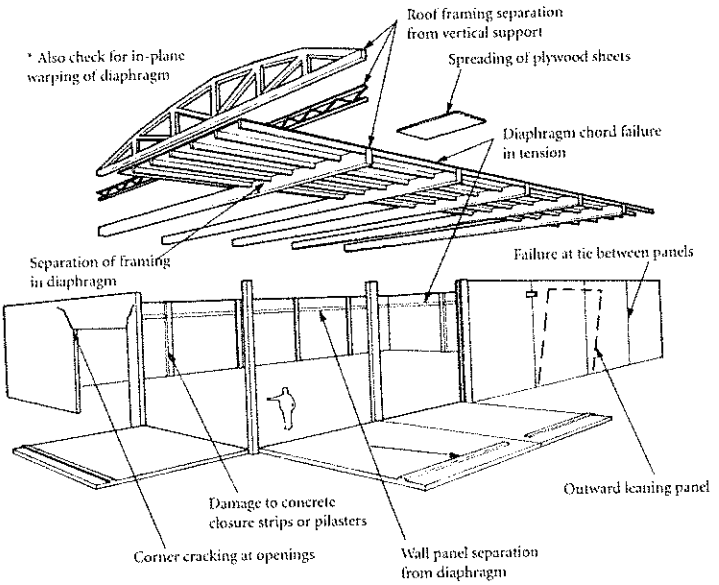


Figure 7-2 Inspection points for tilt-up buildings.

Inspect the building to determine of any of the principal safety concerns listed below exist. There may also be other hazards. For most of the conditions listed, the recommended posting is Unsafe; however, the conditions must be sufficiently hazardous that they endanger the overall building and require the ***entire*** structure to be posted Unsafe. If conditions are locally severe but overall moderate, a Restricted Use posting may be appropriate. In this situation, restrictions may be placed on entry into unsafe areas, or entry restricted to only essential personnel and repair workers.

Condition	Posting
1. Overall Level of Damage	
Collapse or partial collapse	Unsafe
Building noticeably leaning	Unsafe
2. Roof/Floors	
Failed member or connection in roof truss	Unsafe
Roof or floor framing separation from vertical support (Figures 7-3, 7-4 and 7-5)	Unsafe
Other failure or incipient failure of significant vertical-load-carrying element or connection (Figure 7-3)	Unsafe
3. Diaphragms	
Bowed, broken, or seriously damaged diaphragm (Figures 7-4 and 7-5)	Unsafe
Broken or severely damaged chord or collector	Unsafe
Movement or failure at shear connection between diaphragm and wall panel (Figure 7-4)	Unsafe
4. Columns	
Columns noticeably out of plumb	Unsafe
Buckled or failed columns	Unsafe
5. Wall Panels	
Outward leaning panel (Figure 7-6)	Unsafe
Broken or severely damaged closure strips, or a number of broken tie plates	Restricted Use or Unsafe
Wall instability resulting from cracking of panels (Figure 7-7)	Unsafe
Wall, corbel, or pilaster cracking that jeopardizes vertical support of beam or truss (Figure 7-3)	Unsafe

6. Foundations

   Severely fractured foundation..... Unsafe

7. Other

   Falling hazard present (see Chapter 12)..... Restricted Use[1]

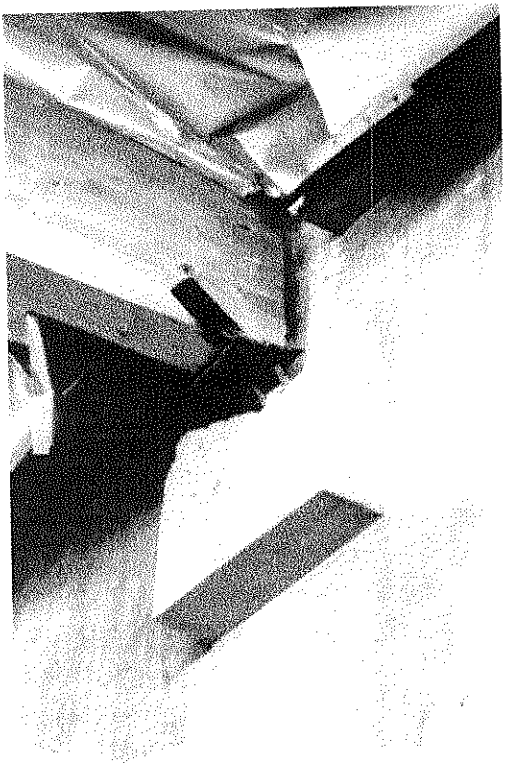


Figure 7-3 Glulam beam with damage to seat and near loss of vertical support. Post Unsafe.

---

1. Barricade unsafe areas.

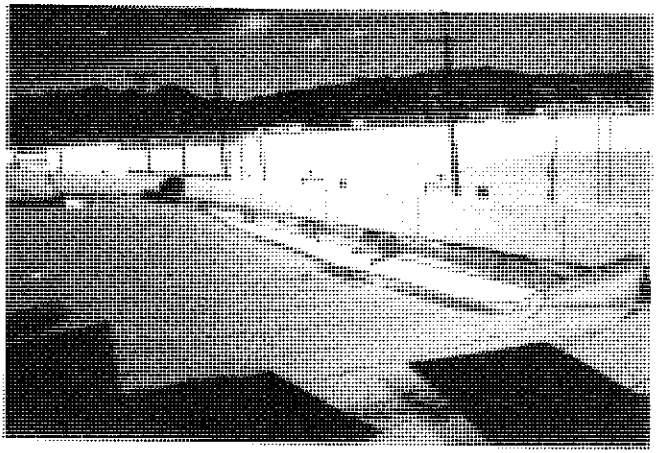


Figure 7-4 The roof of this tilt-up building has pulled away from the supporting walls and is near collapse. Post Unsafe.

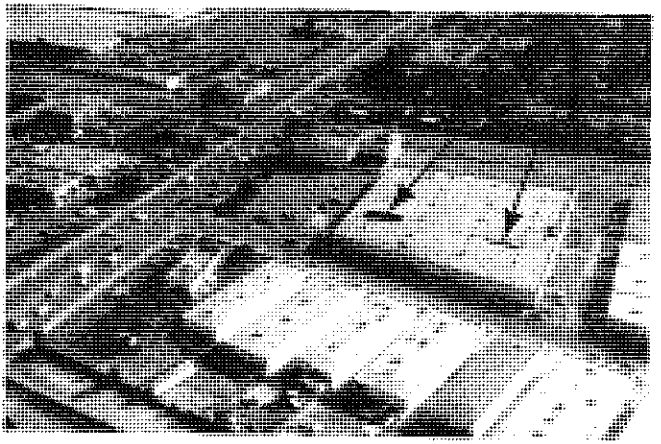


Figure 7-5 The large tilt-up building (center) experienced diaphragm separations and local collapses in its roof. These hazardous conditions can only be found from interior or roof-top inspections. Post Unsafe.

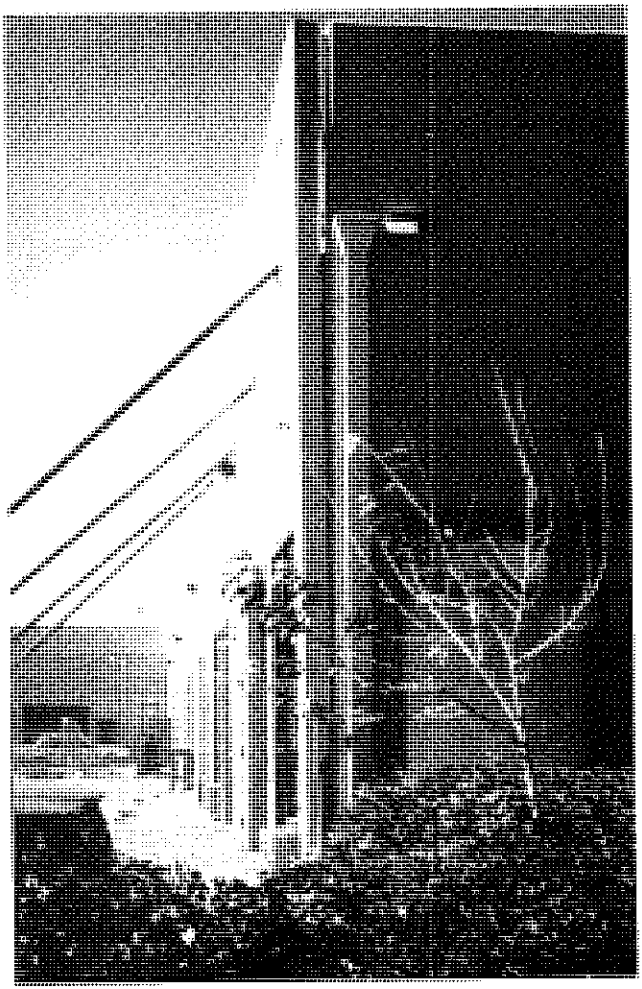


Figure 7-6 A recent tilt-up building with wall-roof separation. The outward-leaning panel has been stabilized with temporary bracing.

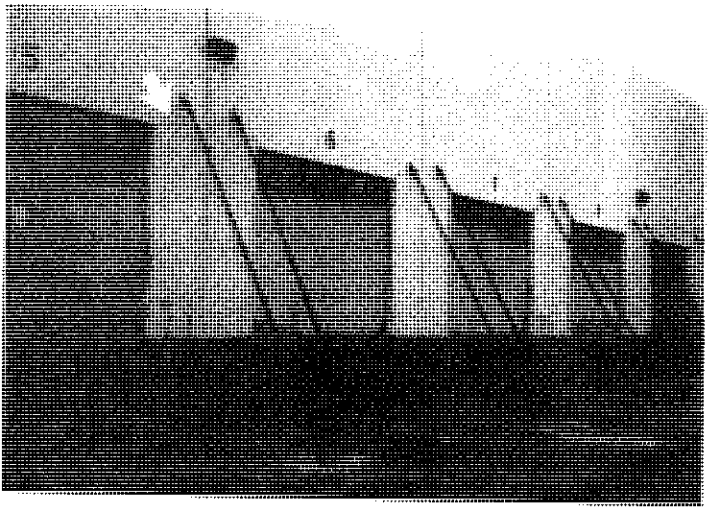


Figure 7-7 Damage investigators need to examine tilt-up panels for cracks in the vicinity of large openings.

8. Inspection and Posting of Concrete Structures

Concrete structures may be cast-in-place, precast, or a combination of the two. Cast-in-place concrete buildings, particularly frame structures built prior to the use of ductile concrete (approximately the mid 1970s) have frequently been damaged in strong earthquakes. These structures can experience deterioration of strength and stiffness, leading to severe damage or even collapse. Piers, spandrel beams, and construction joints in shear walls have also been frequent points of damage. Refer to Figures 8-1 and 8-2 for inspection points for concrete shear wall and frame buildings, respectively.

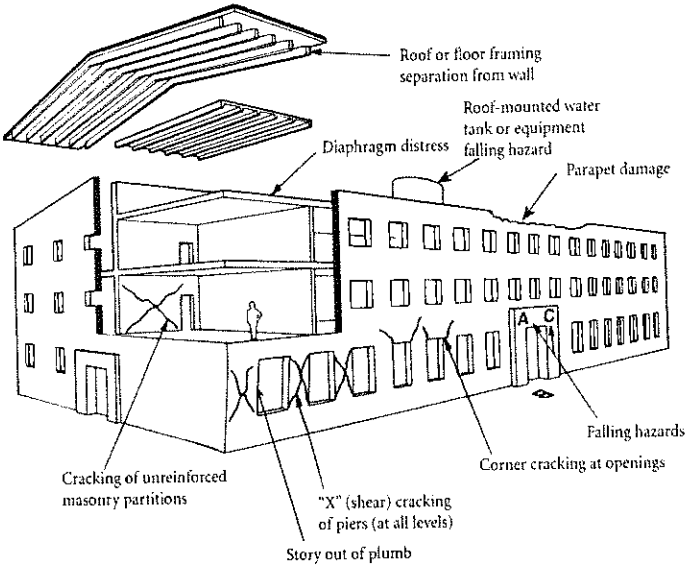


Figure 8-1 Inspection points for reinforced concrete shear wall buildings.

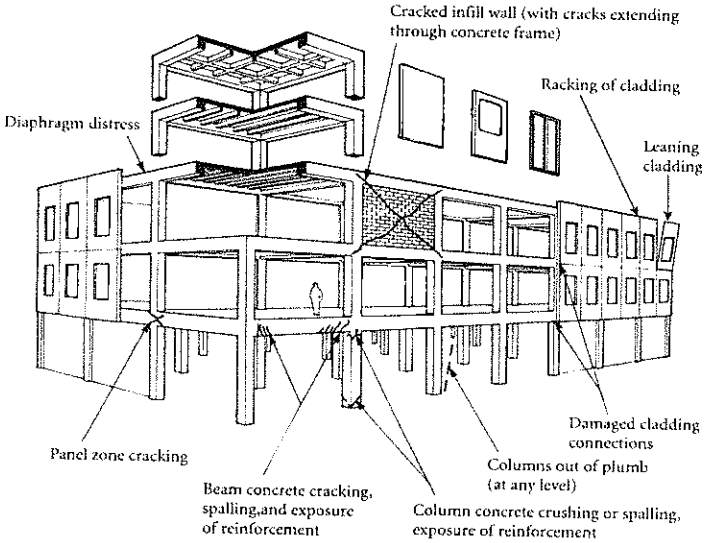


Figure 8-2 Inspection points for reinforced concrete frame buildings.

The principal seismic concerns with precast structures are joints and connections. These may not have the necessary strength and ductility to withstand damage and separation forces. Figure 8-3 illustrates inspection points for precast structures, and Figure 8-4 for lift-slab structures.

Inspect the building to determine if any of the principal safety concerns listed below exist. There may also be other hazards. For most of the conditions listed, the recommended posting is Unsafe; however, the conditions must be sufficiently hazardous that they endanger the overall building and require the *entire* structure to be posted Unsafe. If conditions are locally severe but overall moderate, a Restricted Use posting may be appropriate. In this situation, restrictions may be placed on entry into unsafe areas, or entry restricted to only essential personnel and repair workers.

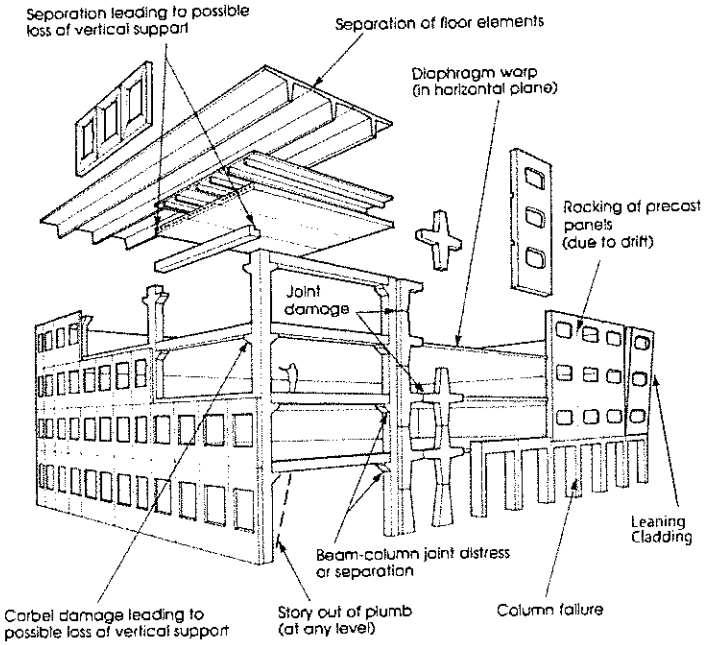


Figure 8-3 Inspection points for precast concrete buildings.

Condition	Posting
1. Overall Damage	
Collapse or partial collapse	Unsafe
Building or individual story noticeably leaning	Unsafe
2. Slabs and Beams	
Separation from vertical support	Unsafe
Flat slab with punching shear cracking or failure at column	Unsafe
Lift-slab-to-column connection cracking or failure	Unsafe

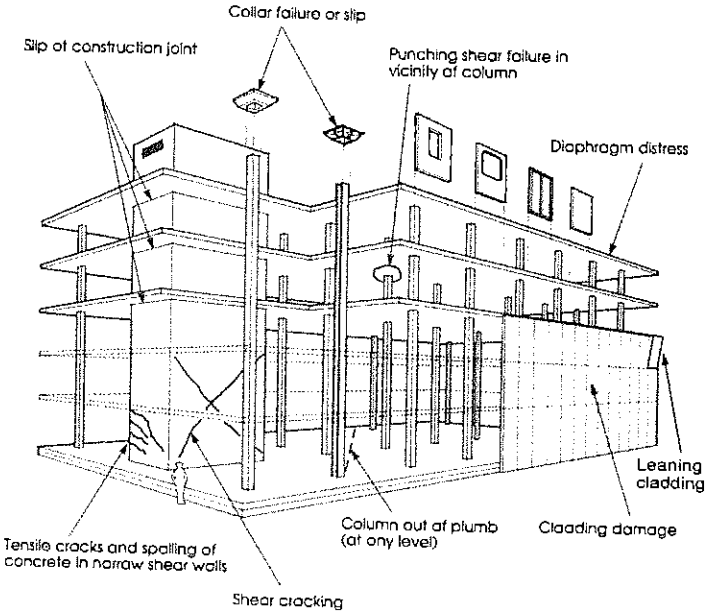


Figure 8-4 Inspection points for lift-slab construction. This figure can also be used for flat-slab structures.

Other failure or incipient failure of significant vertical-load-carrying element or connection..... Unsafe

3. Columns

Buckled or fractured columns (Figure 8-5)..... Unsafe

Massive spalling and exposure of vertical reinforcement (Figure 8-6)..... Unsafe

Large diagonal crack extending through column..... Unsafe

4. Moment Frames

Seriously degraded moment frames (Figure 8-7)..... Unsafe

Severe panel zone cracking (Figure 8-7)..... Unsafe

Noticeable residual drift in any story ..... Unsafe

5. Precast Connections

Failed joints of primary members ..... Unsafe

Corbel or other cracking that jeopardizes vertical support (Figures 8-8 and 8-9) ..... Unsafe

Massive spalled concrete in closure strip ..... Unsafe

6. Horizontal Diaphragms

Broken floor-wall connection ..... Unsafe

Broken or seriously damaged diaphragm ..... Unsafe

7. Solid Shear Walls

Failed shear wall (Figures 8-10 and 8-11) ..... Unsafe

Diagonal (shear) cracks of 1/8-inch wide or more extending between floors ... Restricted Use or Unsafe

Failure or slippage of horizontal construction joint (Figure 8-12) ..... Unsafe

Spalling of concrete and exposure of vertical reinforcement at boundary elements ..... Unsafe

Horizontal cracks 1/8-inch wide or more extending through boundary elements ..... Restricted Use or Unsafe

8. Shear Walls With Openings (Figure 8-13)

Several failed piers at any one story ..... Unsafe

Failed spandrel beams (Figure 8-14) ..... Unsafe

9. Infill Masonry Walls

Infill wall failure (Figures 8-15 and 8-16) ..... Restricted Use or Unsafe

Large infill wall crack extending through concrete frame ..... Unsafe

Infill wall movement along horizontal bedding plane..... Restricted Use

10. Foundations

Severe bowing of underground walls..... Unsafe

Severely fractured foundation..... Unsafe

11. Other

Falling hazard present (see Chapter 12)..... Restricted Use or Unsafe[1]

Engineering Evaluation of Concrete Wall Buildings

Seriously damaged concrete wall buildings can be difficult to evaluate in a Detailed Evaluation and may require an Engineering Evaluation. FEMA 306, *Evaluation of Earthquake Damaged Concrete and Masonry Wall Buildings – Basic Procedures Manual* (ATC, 1998), provides guidelines for both the assessment of individual wall damage and the safety evaluation of the entire building.

1. Barricade unsafe areas.

Figure 8-5 Close-up of fractured column. This column lacks confinement of its vertical reinforcement and has essentially lost its capacity to carry vertical loads. Post Unsafe.

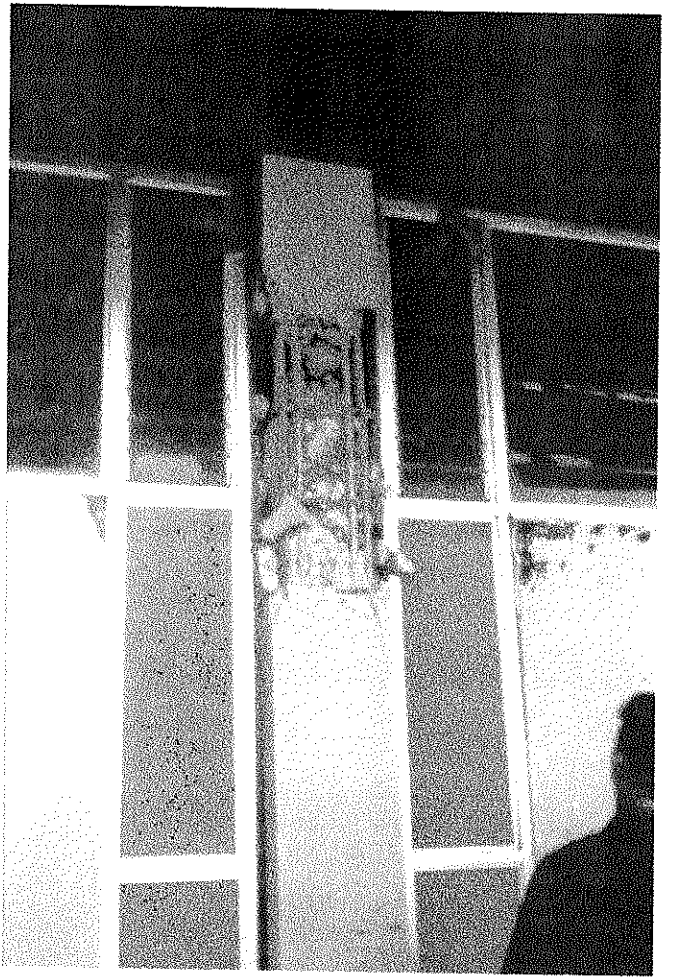


Figure 8-6 Damaged column was restrained by adjacent walls so that it acted as a short column. Post Unsafe.

Figure 8-7 Failure of concrete columns with top and bottom hinging. Post Unsafe.

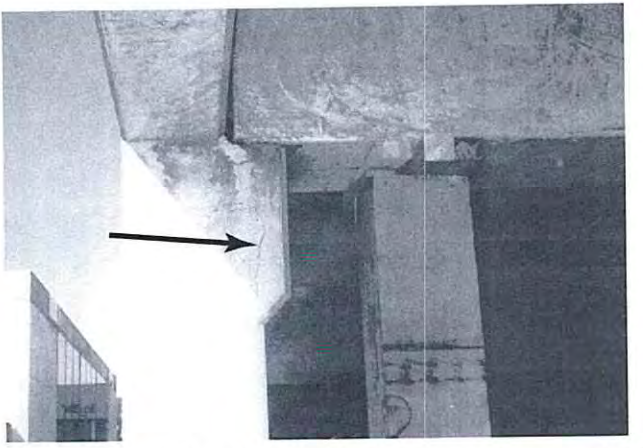


Figure 8-8 Shear crack in the corbel threatens vertical support for the beam. Note the temporary shoring. Initially, post structures like this Unsafe, but after shoring, the posting may be changed, depending on the situation.

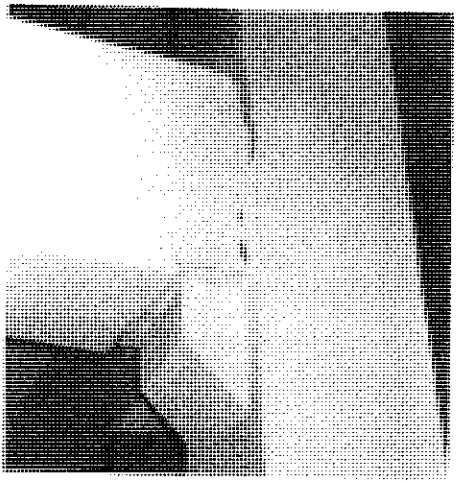


Figure 8-9 Precast concrete beam with such serious cracking at its end that it represents a potential loss of vertical support for the beam. Post Unsafe.

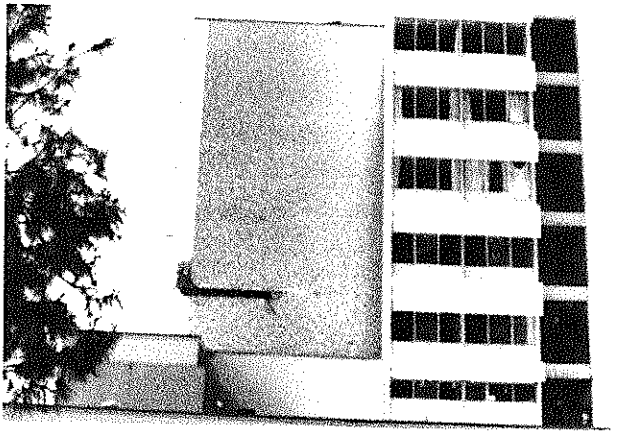


Figure 8-10 Concrete in the floor slab was considerably weaker than that in the shear wall and failed by crushing. Post Unsafe.

Figure 8-11 Shear-wall failure from 1964 Alaska earthquake. Post similarly damaged structures Unsafe.

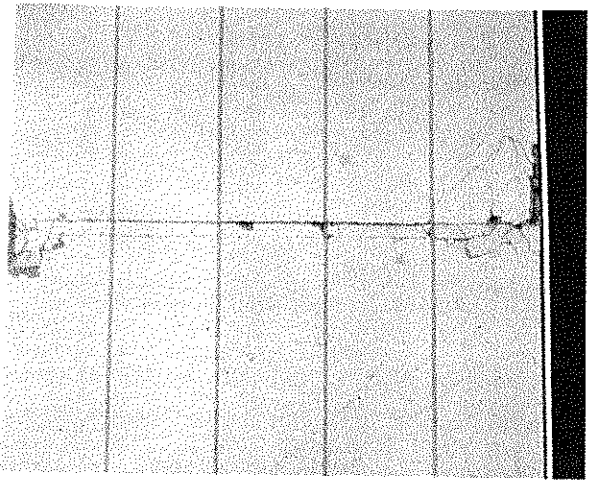
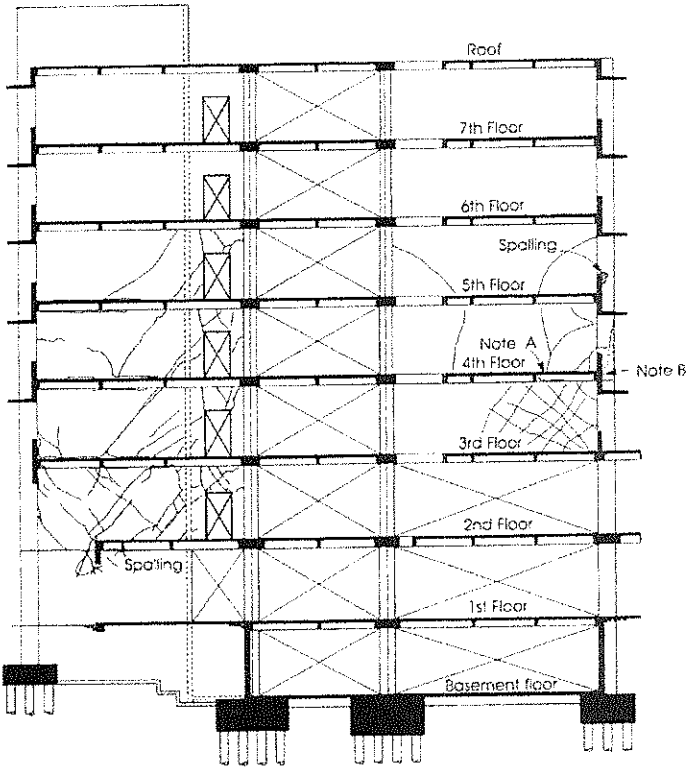


Figure 8-12 Damaged shear wall with slippage along construction joint. The ends of the wall have spalled due to overturning forces. Post Unsafe or Restricted Use.



Notes:
A. Floor and wall separated 1-1/4"
B. Concrete completely crushed; reinforcement exposed

Figure 8-13 Assessment of damage to a large shear wall can be enhanced if a sketch is developed showing an elevation of the wall and indicating areas of cracking, spalling, and exposure of reinforcement.

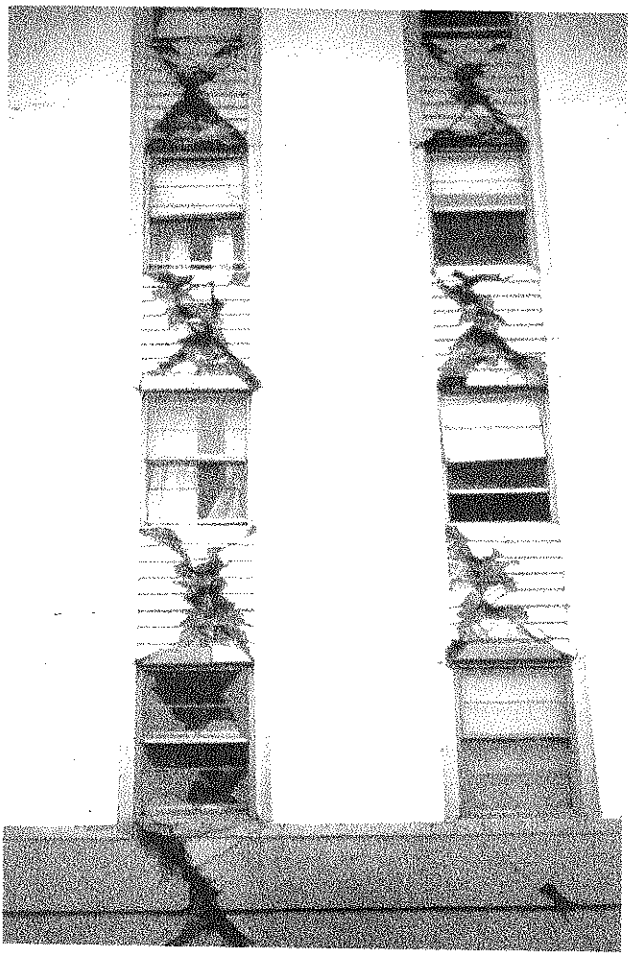


Figure 8-14 Failed spandrel beams of the building shown in Figure 8-11. Post similarly damaged buildings Unsafe.

Figure 8-15 Damage to infill concrete masonry unit (CMU) walls from the 1964 Alaska earthquake. Post similarly damaged buildings Unsafe or Restricted Use due to loss of lateral resistance.

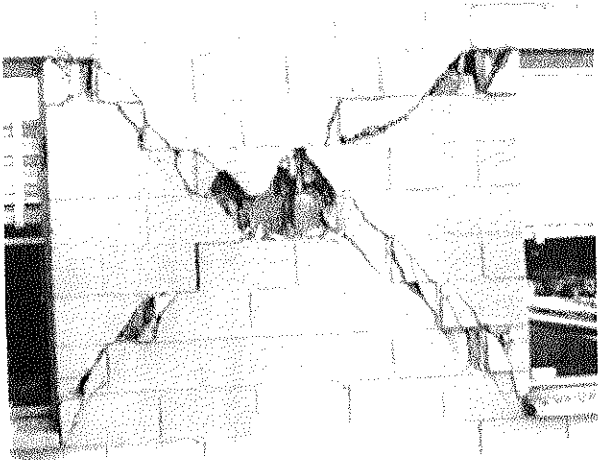


Figure 8-16 Close-up of shear failure of CMU pier in the structure shown in Figure 8-15.

9. Inspection and Posting of Steel-Frame Structures

Steel-frame structures have generally had a good performance record, particularly in avoiding collapse. However, they can be seriously damaged. Braced steel frames may sustain broken or buckled braces or broken connections. Moment-frame structures may have damage to primary members, cracking of welds and other distress at moment connections, and residual story drift. The latter can increase the potential for collapse, particularly in multi-story buildings. In multi-story buildings, it is particularly important to assess the integrity of the vertical (gravity) load-carrying system. Unreinforced masonry infill walls of steel-frame structures can become sufficiently cracked that the masonry becomes a falling hazard.

Figure 9-1 illustrates inspection points for one-story light steel-frame structures, and Figure 9-2 illustrates those for older steel-frame buildings.

Inspect the building to determine if any of the principal safety concerns listed below exist. There may also be other hazards. For most of the conditions listed, the recommended posting is Unsafe; however, the conditions must be sufficiently hazardous that they endanger the overall building and require that the *entire* structure to be posted Unsafe. If conditions are locally severe but overall moderate, a Restricted Use posting may be appropriate. In this situation, restrictions may be placed on entry into unsafe areas, or entry may be restricted to only essential personnel and repair workers.

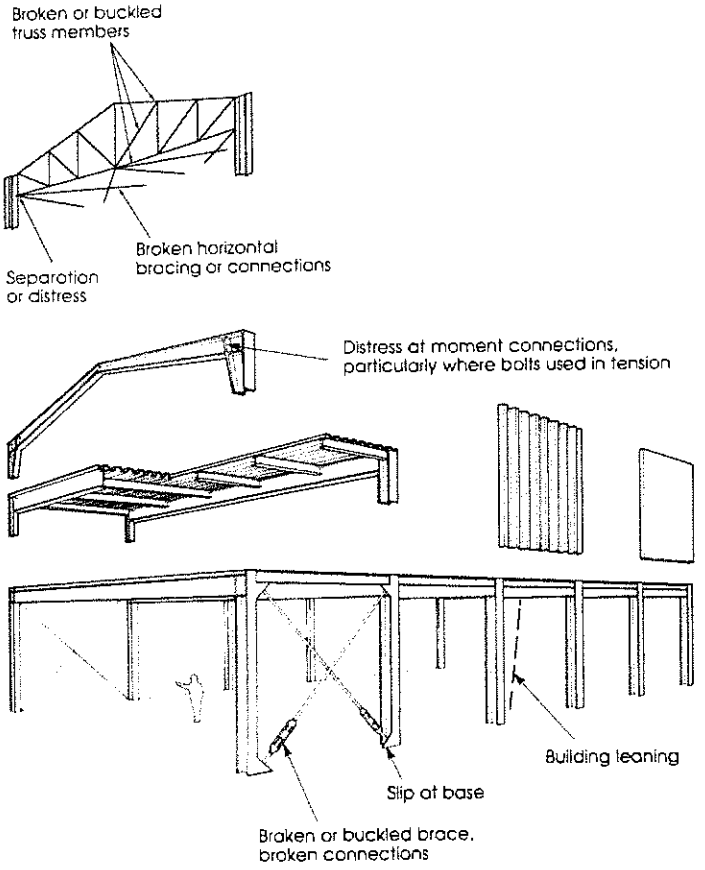


Figure 9-1 Inspection points for light braced steel-frame buildings.

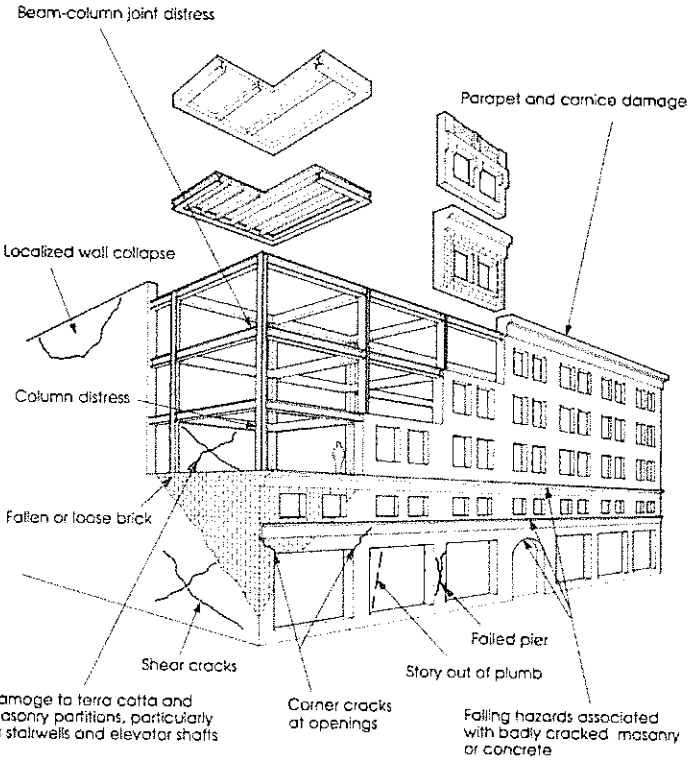


Figure 9-2 Inspection points for older steel-frame buildings. New steel-frame buildings often have cladding instead of solid masonry or concrete walls as shown above.

Condition	Posting
1. Overall Damage	
Collapse or partial collapse	Unsafe
Building or individual story noticeably leaning	Unsafe
Prefab building with residual story drift of two inches or more per story (10 feet)	Unsafe
2. Roof and Floor Framing	
Broken or buckled member in truss	Unsafe
Failed connection in truss	Unsafe
Roof or floor framing separation from vertical supports	Unsafe
Other failure or incipient failure of significant vertical-load-carrying element or connection	Unsafe
3. Columns	
Columns noticeably out of plumb	Unsafe
Buckled or failed columns (Figures 9-3 and 9-4)	Unsafe
Shear failure at column base connection	Unsafe
4. Vertical Bracing	
Buckled or greatly stretched brace (Figures 9-5 and 9-6)	Unsafe
Broken brace or connection (Figure 9-7)	Unsafe
5. Horizontal Bracing	
Broken brace or connection	Unsafe
Buckled or greatly stretched brace	Unsafe
Failed chord	Unsafe

6. Horizontal Diaphragms

Bowed, broken, or seriously damaged diaphragm ..... Restricted Use or Unsafe

Broken or seriously damaged chord or collector ..... Unsafe

Movement or failure at shear connection between diaphragm and beam ..... Unsafe

Horizontal cracks 1/2-inch wide or larger in concrete structural slabs..... Unsafe

7. Moment Frames[1]

Broken, leaning, or seriously degraded moment frames ..... Unsafe

Significant weld or other connection failure at moment joint ..... Unsafe

Flange buckling near moment joints ..... Unsafe

Noticeable residual story drift at any level..... Unsafe

8. Foundations

Bowing of underground walls..... Unsafe

New fractures 1/2-inch wide or more in basement floor slabs..... Restricted Use or Unsafe

Severely Fractured foundation ..... Unsafe

9. Other

Unreinforced infill masonry walls with large cracks and/or spalling ..... Restricted Use[2]

Falling hazard present (see Chapter 12)..... Restricted Use[2]

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1. Refer to FEMA 352 (SAC, 2000) for additional information on conducting a Detailed Evaluation of steel moment-frame structures. (An ATC-20 Detailed Evaluation corresponds to a FEMA 352 Preliminary Postearthquake Assessment.)
2. Barricade unsafe area.

When an Engineering Evaluation is Required

Structural engineers performing Detailed Evaluations of steel-frame buildings must be concerned about the possibility of serious damage that cannot be seen because it is covered by architectural finishes and fireproofing. When ground motions are sufficiently high, an Engineering Evaluation needs to be done, and finishes and fireproofing removed.

For steel moment-frame structures, Table 9-1 indicates ground motion levels and damage level indicators (to other building types) that are considered as threshold indicators for initiating the Engineering Evaluation. These are from FEMA 352, *Recommended Postearthquake Evaluation and Repair Criteria for Welded Steel Moment-Frame Buildings* (SAC, 2000). This document provides guidance on conducting an Engineering Evaluation. (An ATC-20 Engineering Evaluation of a steel moment frame building corresponds to a FEMA 352 Level 1 or Level 2 Detailed Postearthquake Evaluation.) Figure 9-8 shows a moment connection with fireproofing removed as part of an Engineering Evaluation.

For braced-frame buildings, unfortunately, there is no similar guidance available. As an ***interim*** measure, the threshold indicators of Table 9-1 can also be used for initiating Engineering Evaluations of braced frames. Individual members and connections must be sufficiently exposed that the soundness of the entire brace assembly can be readily determined. Damage shown in Figures 9-6 and 9-7 was found only after finishes were removed.

Table 9-1. Indicators[a] of Ground Motion Severity for Initiating Engineering Evaluations of Steel Moment Frame Structures (from SAC, 2000)

Seismic Risk of Site[b]	Peak Ground Acceleration (PGA)	Damage Level to other buildings within 1 Kilometer of Site	Modified Mercali Intensity (MMI)
$S_s \geq 0.50g$[c]	≥ 0.25 g	Prevalent partial collapse of unreinforced masonry buildings. High levels of nonstructural damage. Considerable damage to ordinary buildings.	VIII
$0 < S_s < 0.50g$	≥ 0.15 g	Considerable damage to unreinforced masonry buildings. Slight damage to well designed buildings. Prevalent nonstructural damage.	VII

a. At or above these ground-motion severity indicators, an Engineering Evaluation is recommended. (Note: Appendix F lists possible sources for information on ground shaking severity experienced at the site during the earthquake.)

b. Based on 1997 National Earthquake Hazards Reduction Program (NEHRP) Maximum Considered Earthquake Maps

c. Approximately equivalent to *Uniform Building Code* Zones 3 and 4 for purposes of this table.

S_s = Short period acceleration response

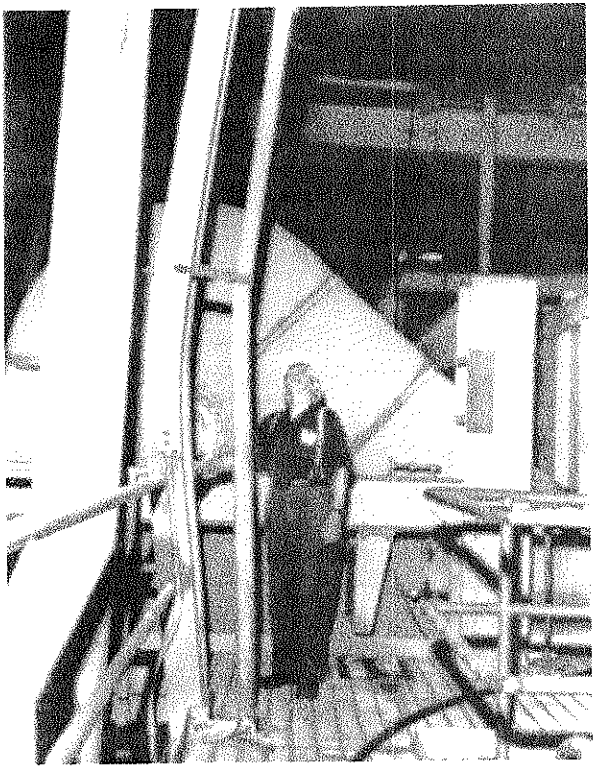


Figure 9-3 Bowed column in steel-frame structure. Buildings with similar kinds of damage should be posted Restricted Use or Unsafe, depending on the severity and extent of the damage.

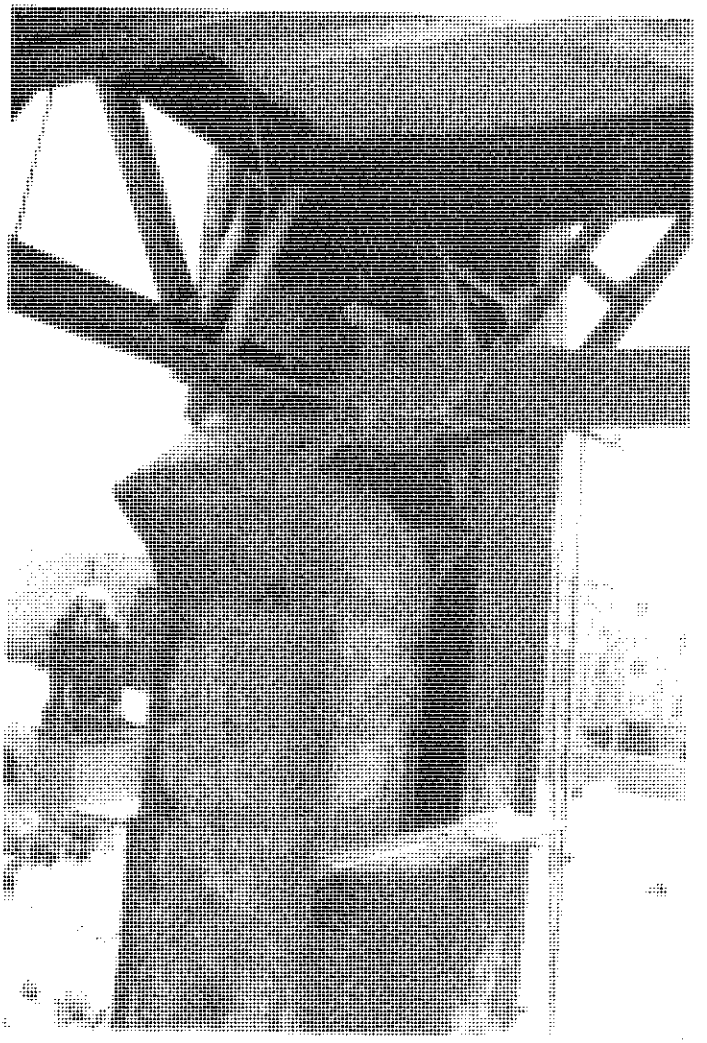


Figure 9-4 Local column buckling of this type constitutes a clearly unsafe situation. Post Unsafe.

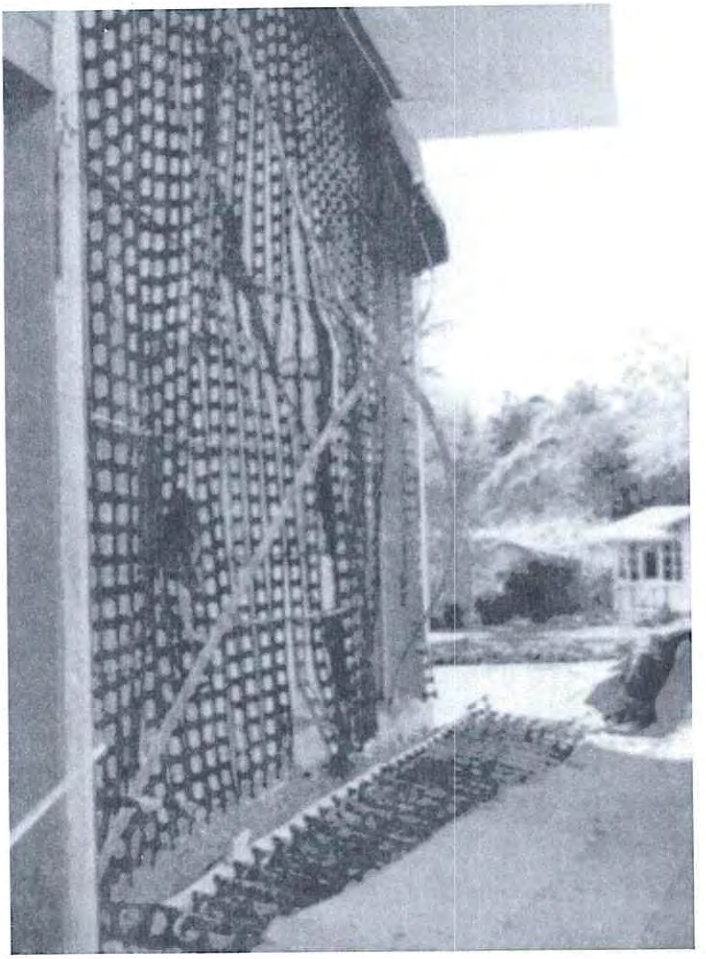


Figure 9-5 This greatly stretched x-bracing is no longer effective. Post similarly damaged buildings Restricted Use or Unsafe.

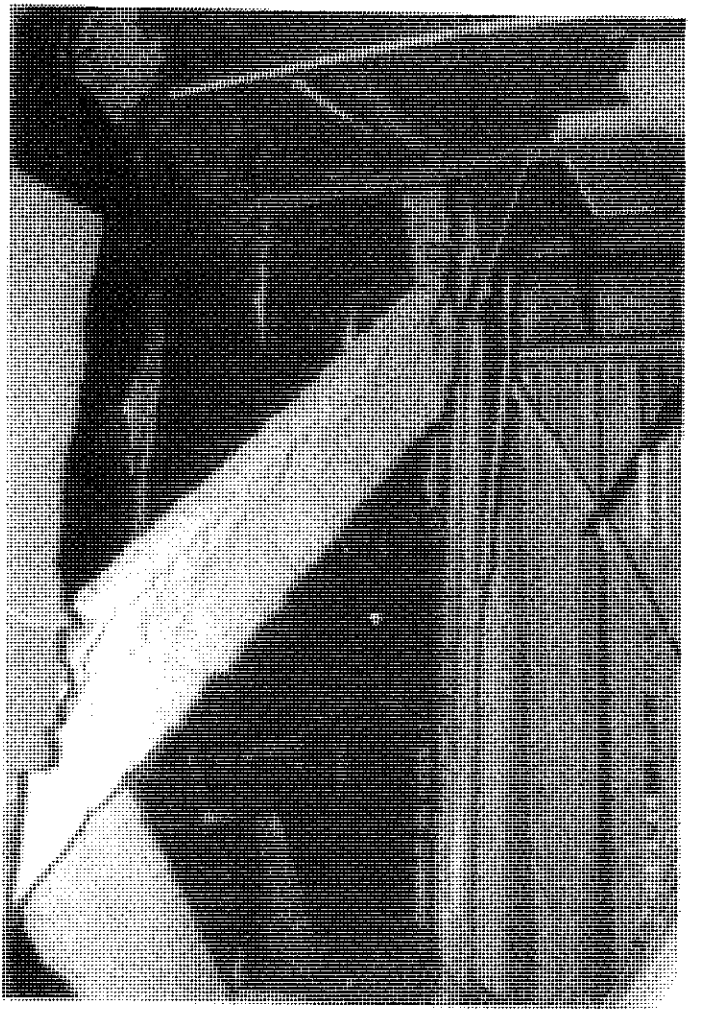


Figure 9-6 Bent (buckled) steel channel of x-bracing.

Figure 9-7 This steel tube brace has completely failed. There were few signs of distress until the wallboard finish and fireproofing were removed.

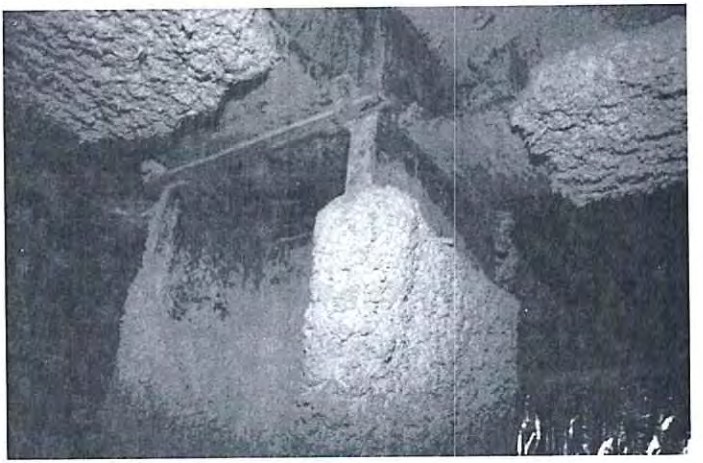


Figure 9-8 The fireproofing on this moment connection was removed to facilitate an Engineering Evaluation of a five-story steel-frame building.

10. Inspection and Posting of Mobile Homes and Manufactured Housing

Mobile homes have evolved from the small trailer pulled behind an automobile to manufactured housing. In the latter form, it is common for two 12 × 60-foot units to be towed to a mobile home park and assembled to form a 24 × 60-foot "double-wide" home. Single-, triple-, and quadruple-wide homes are also common. Because each unit must be designed for highway travel and erection, there have been few reports of superstructure damage caused by earthquake shaking alone.

Mobile homes are frequently supported vertically on steel jacks, concrete piers, or stacked concrete blocks. Often they are only vertically supported and lack any seismic bracing between the ground and the undercarriage.

The principal damage to mobile homes has been falling off vertical supports because of lack of foundation bracing, with subsequent damage to the undercarriage, utilities, awnings, porches, and skirts (Figures 10-1 and 10-2). This kind of damage is very similar to that frequently experienced by older wood-frame dwellings (see Chapter 5).

Unbraced gas water heaters are also a hazard. These can fall over and may lead to postearthquake fire. Fire can also be caused when unbraced mobile homes fall off vertical supports and break gas service lines.

Inspect the mobile homes to determine if any of the common safety concerns listed below exist. There may be other hazards than those listed. Figure 10-1 indicates inspection points for mobile homes. Follow the recommended posting (or action). For many of the conditions listed, the recommended posting is Unsafe; however, the

condition observed must be sufficiently hazardous that it requires the *entire* home not be occupied. If not, post the home Restricted Use, and place appropriate restrictions on its use or occupancy.

Condition	Posting
1. Overall Damage	
Collapse or partial collapse	Unsafe
Separation between two parts of a home	Unsafe
2. Walls	
Walls racked with residual lean of 1 to 2 inches or more	Unsafe
3. Floors	
Out-of-level but structurally stable	Restricted Use or Unsafe
Jackstands penetrating floor	Restricted Use or Unsafe
4. Foundations	
Home off vertical supports	Unsafe
5. Other Hazards	
Blocked or jammed exits	Restricted Use or Unsafe
Partially burned	Restricted Use or Unsafe
Canopy or awning falling hazard	Restricted Use
Gas leak	Restricted Use
Overturned gas water heater	Restricted Use
Porch collapse	Restricted Use or Unsafe

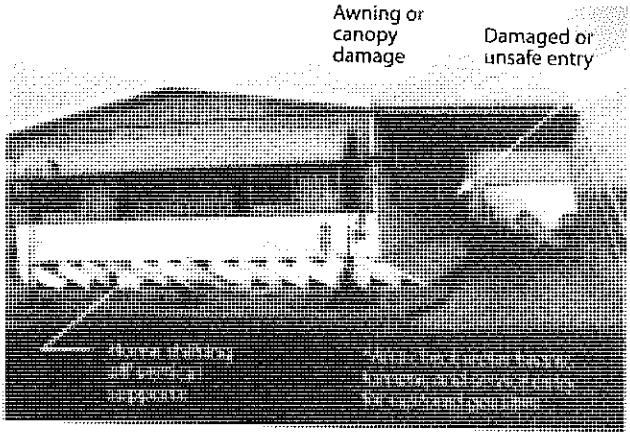


Figure 10-1 Inspection points for mobile homes. Post similarly damaged homes Unsafe.

Figure 10-2 Mobile homes that are not braced between the foundation and the undercarriage often collapse in strong shaking. Damage to this mobile home not only includes collapse of vertical supports, but also damage to the undercarriage and porch. Post Unsafe.

11. Inspection and Posting of Geotechnical Hazards

Geotechnical conditions such as large settlements or lateral spreading of soil beneath buildings can severely damage structures, including those otherwise resistant to ground shaking. Ground movements associated with surface fault rupture can also damage well designed construction.

When geotechnical hazards are suspected (Figure 11-1), the safety evaluation should be done by qualified geotechnical specialists. Inspection points for some geotechnical hazards are illustrated in Figure 11-2.

Examine the general area affected by the suspected hazard. Determine if any of the safety concerns listed below exist. There may also be other hazards. For most of the conditions listed, the recommended posting is Unsafe; however, the conditions must be sufficiently hazardous that they endanger the overall safety of a structure and require the structure to be posted Unsafe. In some instances, a Restricted Use posting may be appropriate with restrictions placed on entry into unsafe areas, or entry restricted to only essential personnel and repair workers.

Condition	Posting
1. Surface Fault Rupture	
Building damaged by fault rupture (Figure 11-3)	Unsafe
2. Slope Failures	
Slope failure has caused foundation damage or loss of foundation support (Figure 11-4)	Unsafe
Slope movement continuing under static conditions	Unsafe[1]
Building in active slope failure zone	Unsafe[1]

Building in path of debris, including rock fall (Figure 11-5), from active slope failure zone..... Unsafe[1]

Retaining wall leaning outward 5° (1:12 slope) or more relative to vertical ..... Restricted Use[1]

3. Other Differential Ground Movements

Building damaged by ground displacement (Figures 11-6 and 11-7)..... Unsafe

Ground fissures and scarps more than 4 inches wide near buildings ..... Unsafe

4. Earth Dam or Reservoir Movement

Large cracks, increased seepage, or embankment failure in earth dam ..... Unsafe[1]

Overtopping of dam by wave ..... Unsafe[1]

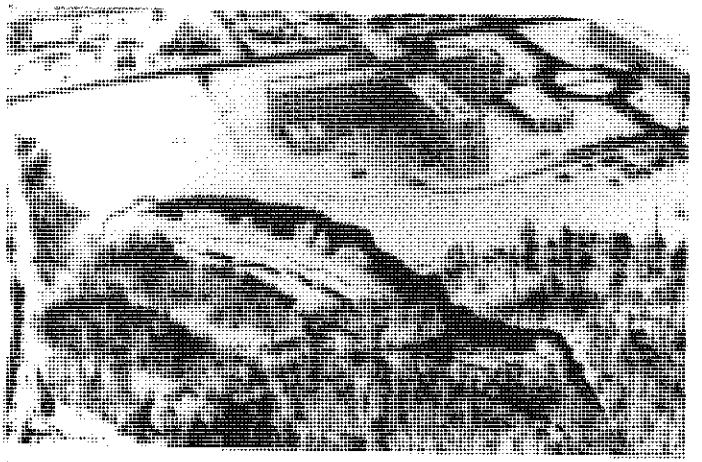


Figure 11-1 Whenever a large slide appears to threaten the safety of buildings, geotechnical specialists should assess the possibility of further movement.

1. Barricade unsafe areas.

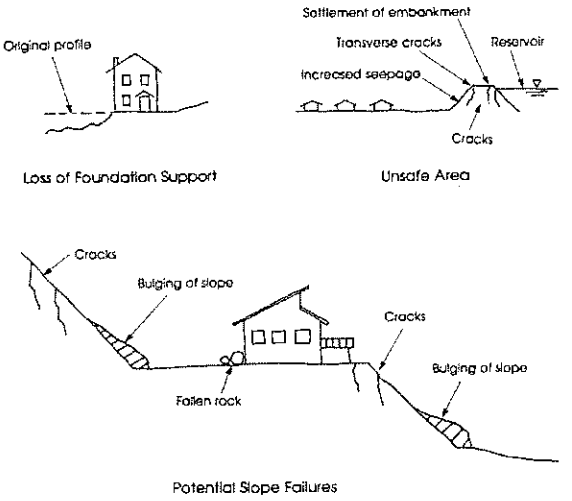


Figure 11-2 Inspection points for some geotechnical hazards.

Figure 11-3 House damaged by ground displacement caused by surface faulting from the 1971 San Fernando, California, earthquake. Post Unsafe.

Figure 11-4 House and street damaged by several inches of landslide displacement caused by San Fernando earthquake. Post Unsafe.

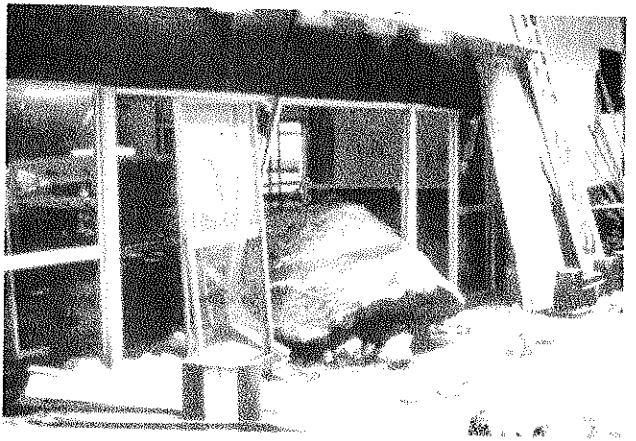


Figure 11-5 Damage to store front caused by rock fall.

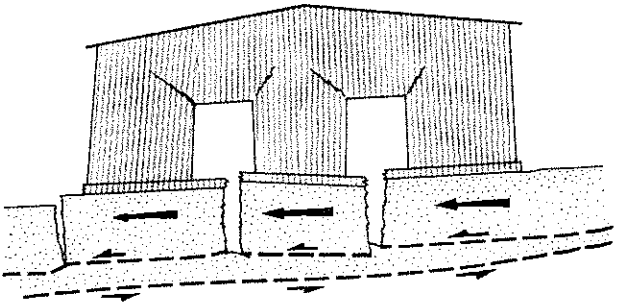


Figure 11-6 Drawing depicting lateral spread of soil and subsequent damage to San Fernando Valley Juvenile Hall during the 1971 San Fernando, California, earthquake.

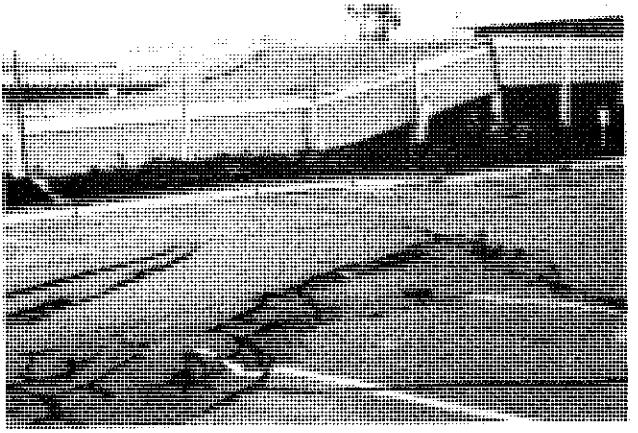


Figure 11-7 Damage to the San Fernando Valley Juvenile Hall caused by lateral spreading. Post Unsafe.

12. Inspection and Posting of Nonstructural Hazards

In addition to the obvious life-safety concerns related to the stability of a building as a whole, damage to nonstructural elements can also create hazards. For example, a weakened parapet may fall in an aftershock, or a cracked gas line to a boiler may result in a postearthquake explosion and fire.

Inspect the building to determine if any of the common safety concerns listed below exist. Elevators and fire protection/detection equipment should be inspected by specialists. Refer to Appendix C for guidance whenever a spill or release of a hazardous or unknown material is encountered.

The posting recommendations given below are the recommended postings for the building or structure affected by the individual hazardous condition. Generally, nonstructural damage alone is not grounds for posting an entire building Unsafe. However, if the hazards are severe, life-threatening, and widespread, it may be necessary. It is recommended that the Restricted Use posting be used whenever possible, with restrictions placed either on entry into unsafe areas, or entry restricted to essential personnel and repair workers. For buildings with very minor nonstructural hazards, the Inspected placard, with appropriate barricading, may be used.

Condition	Posting[1]
1. Parapets, Ornamentation, and Appendages	
Partially dislodged masonry parapets	Restricted Use
Masonry parapets with cracking (no evidence of reinforcement)	Restricted Use

1. Barricade unsafe areas to prevent entry.

Concrete parapets with major spalling or severe lean ..... Restricted Use

Ornamentation/cornices/signs/mansards with support distress or partial dislodgement ..... Restricted Use

Fallen or damaged veneer (Figure 12-1) or roof tile ..... Restricted Use

2. Canopies

Partial collapse or lean of canopy (Figure 12-2) ..... Restricted Use

Failure or incipient failure of support for canopy, awning or marquee ..... Restricted Use

3. Cladding

Falling hazard from damaged glazing ..... Restricted Use

Broken or damaged cladding (Figure 12-3) ..... Restricted Use

Walls with some fallen panels ..... Restricted Use

4. Ceilings and Light Fixtures

Collapse, partial collapse, or incipient collapse of ceiling (Figure 12-4) ..... Restricted Use

Pendant fluorescent light fixtures with damaged stems ..... Restricted Use

Area with some fallen light fixtures (Figure 12-5) or possible falling hazard ..... Restricted Use

5. Interior Walls, Partitions, and Glazing

Collapsed, partially collapsed, or severely cracked partitions (Figure 12-6) ..... Restricted Use

Cracked masonry or tile partitions (no evidence of reinforcement) ..... Restricted Use

Demountable partitions separated from supports ..... Restricted Use

Possible falling glass hazard ..... Restricted Use

6. Mechanical and Electrical Equipment

Overturning or sliding of gas- and fuel-oil-fired equipment (Figure 12-7) ..... Restricted Use[2]

Gas or fuel line break or leak ..... Restricted Use[2]

Broken exhaust pipe ..... Restricted Use[2]

Overhead piping and ducts with failed supports ..... Restricted Use

Other mechanical and electrical equipment falling hazard present ..... Restricted Use

7. Elevators

Inspection points for traction elevators are shown in Figure 12-8. Passenger elevators in California with automatic operation and counterweights are provided with an earthquake protective device. Elevators posted Unsafe, including those with protective devices, should not be used.

Suspected damage ..... Unsafe

Elevator with protective switch tripped ..... Unsafe

Counterweights out of guides ..... Unsafe

Damaged guiding member ..... Unsafe

Damaged guide rails or brackets ..... Unsafe

Equipment anchorage failure ..... Unsafe

Cables out of sheaves ..... Unsafe

Door damage ..... Unsafe

8. Other

Spill of known or suspected dangerous materials ..... Restricted Use[1]

---

1. Barricade unsafe areas to prevent entry.
2. Equipment must not be used.

Leakage of unknown substance from tank, pressure vessel, or piping..... Restricted Use[1]

Friable asbestos release ..... Restricted Use or Unsafe[1]

Fire protection/detection equipment inoperable..... Restricted Use

Fallen electric lines..... Restricted Use[1]

Unsafe condition at stairway, exitway, or inoperable exit door..... Restricted Use[3]

Raised access floor with collapse potential ..... Restricted Use

Figure 12-1 Damaged brick veneer can be a falling hazard. Post Restricted Use and barricade unsafe area.

1. Barricade unsafe areas to prevent entry.
3. Post entire building Unsafe whenever all exits are blocked or otherwise unusable.

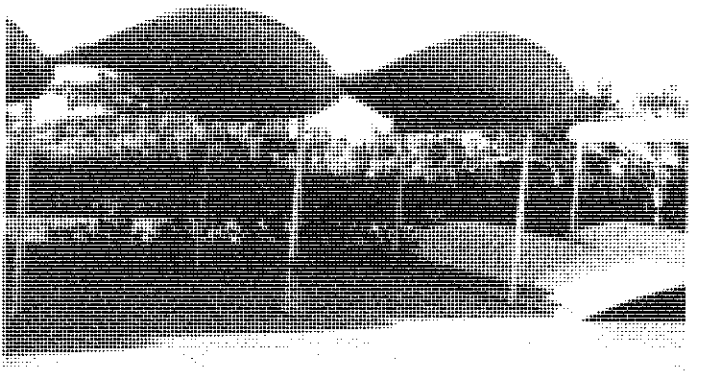


Figure 12-2 Leaning canopy. Barricade the unsafe area.

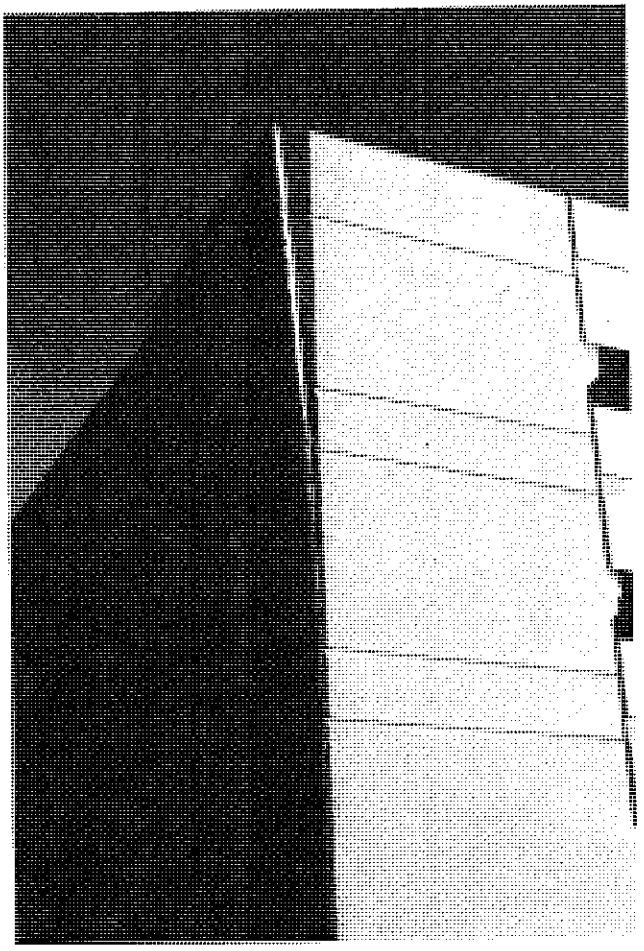


Figure 12-3 Damaged cladding can become a falling hazard. If the falling hazard can affect an adjacent building, it may be necessary to post the adjacent building Restricted Use or Unsafe, depending on the circumstances. As a minimum, this parking structure should be posted Restricted Use.

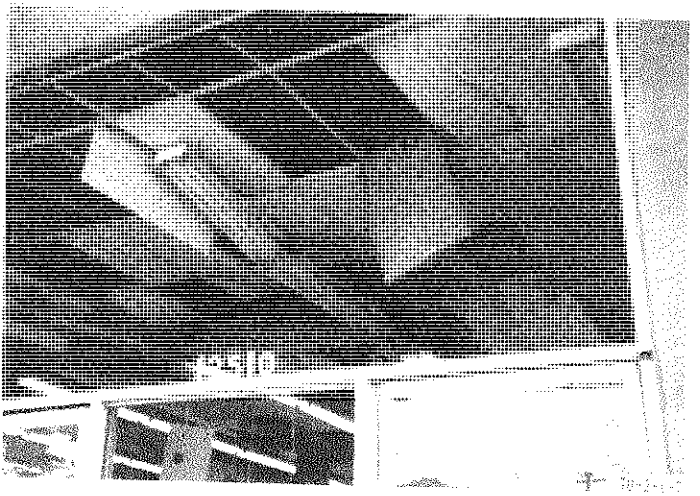


Figure 12-4 Damage to suspended ceiling system and light fixtures. Post Restricted Use and barricade the unsafe area.

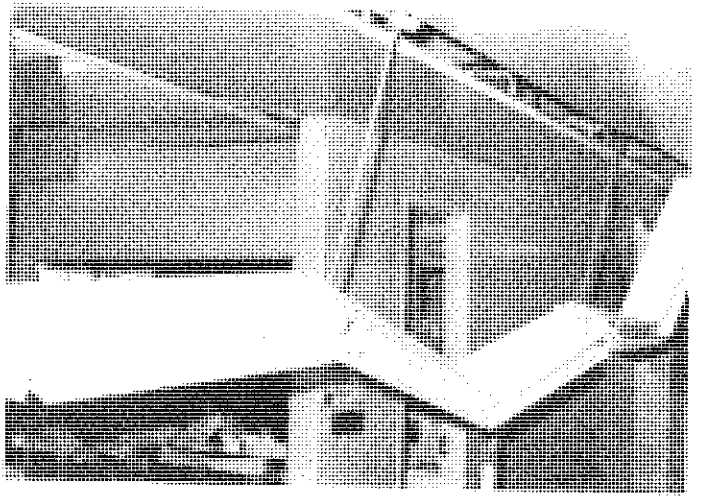


Figure 12-5 Fallen recessed fluorescent light fixtures. Post Restricted Use and barricade the unsafe area.

Figure 12-6 Severe damage to unreinforced masonry partition. Post Restricted Use and barricade the unsafe area.

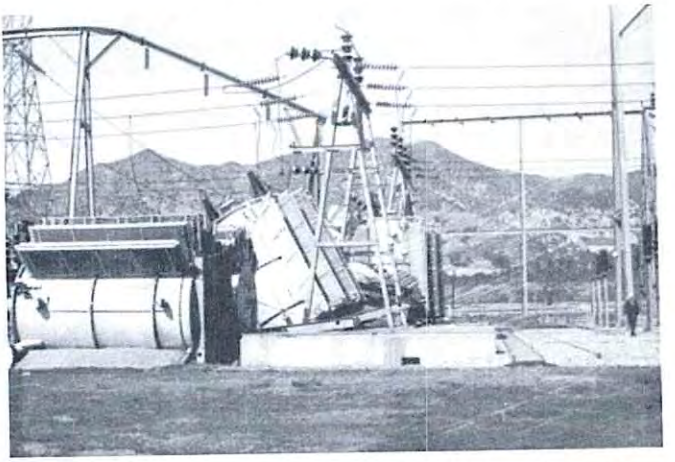


Figure 12-7 The single most important contributor to equipment damage is lack of anchorage. These large electrical transformers overturned, spilling oil.

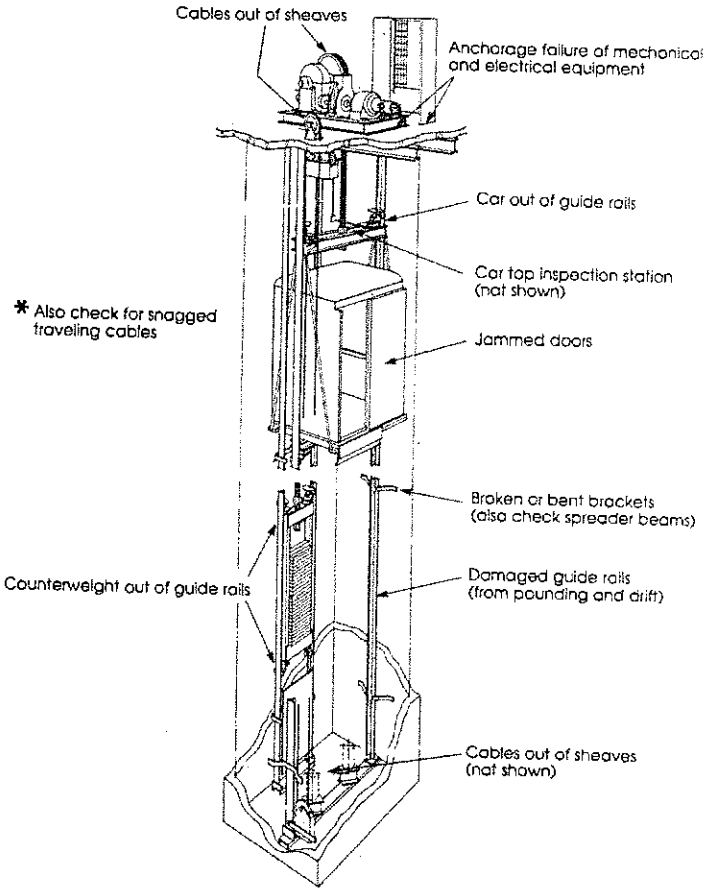


Figure 12-8 Inspection points for typical traction elevators. Hoistway inspections can be made only from the car top or elevator pit and should be performed by a qualified person.

13. Inspection of Essential Facilities

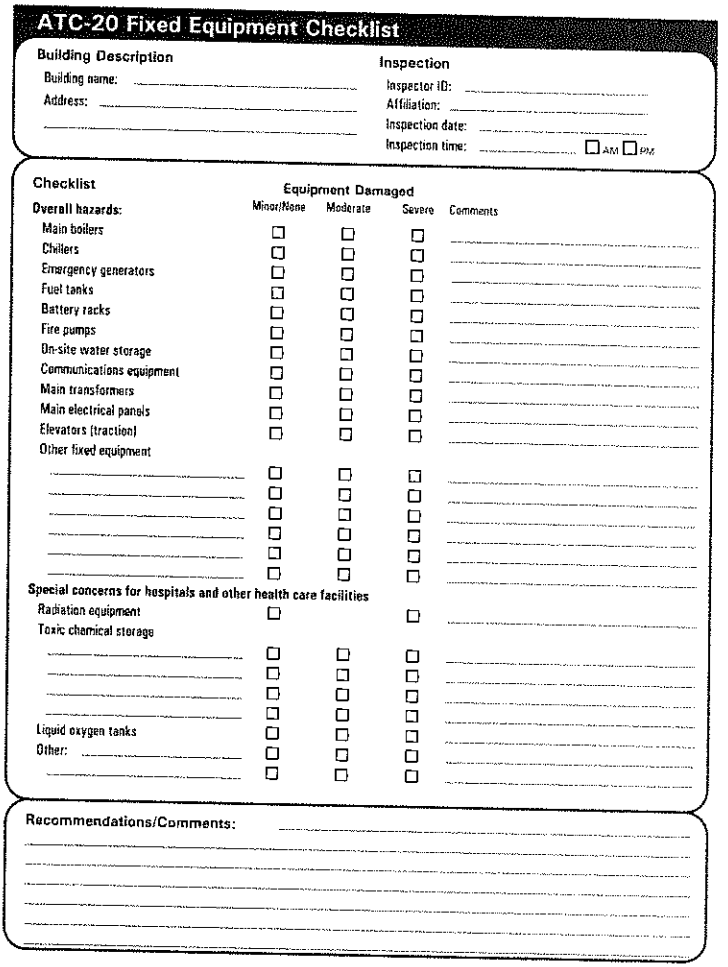
Essential facilities are those facilities most needed by a community following an earthquake disaster. They must be structurally safe, should have no falling or other hazards, and be in operable condition. Examples of essential facilities include, but are not limited to:

- Hospitals
- Health care facilities
- Police and fire stations
- Jails and detention centers
- Communication centers
- Emergency operations centers

Inspection of essential facilities differs from that of ordinary construction in the following ways:

1. *First Priority.* Essential facilities should be given the first priority for safety evaluation.
2. *Require Detailed Evaluation.* If any damage is suspected, a Detailed Evaluation (Chapter 4) of the building should be made, preferably by a team of at least two structural engineers or other specialists. (e.g., elevator engineer, geotechnical engineer) as needed.
3. *Check Fixed Equipment.* Because essential facilities must remain operational, fixed equipment should be inspected. This can be done using the Fixed Equipment Checklist (Figure 13-1). The principal concerns for each item are indicated in Table 13-1; however, there may be other issues.
4. *Check Fire Protection and Elevator Systems.* These systems must be in working order. They should be examined by appropriate specialists.
5. *Coordinate Damage Inspections.* Coordinate efforts with appropriate government agencies. (In some states, the state rather

than the local jurisdiction has authority and responsibility for safety evaluation and posting of certain kinds of essential facilities.)



ATC-20 Fixed Equipment Checklist

Building Description

Building name: _____

Address: _____

_____

Inspection

Inspector ID: _____

Affiliation: _____

Inspection date: _____

Inspection time: _____ ☐ AM ☐ PM

Checklist

	Equipment Damaged			
Overall hazards:	Minor/None	Moderate	Severe	Comments
Main boilers	☐	☐	☐	
Chillers	☐	☐	☐	
Emergency generators	☐	☐	☐	
Fuel tanks	☐	☐	☐	
Battery racks	☐	☐	☐	
Fire pumps	☐	☐	☐	
On-site water storage	☐	☐	☐	
Communications equipment	☐	☐	☐	
Main transformers	☐	☐	☐	
Main electrical panels	☐	☐	☐	
Elevators (traction)	☐	☐	☐	
Other fixed equipment				
_____	☐	☐	☐	
_____	☐	☐	☐	
_____	☐	☐	☐	
_____	☐	☐	☐	
_____	☐	☐	☐	
_____	☐	☐	☐	
Special concerns for hospitals and other health care facilities				
Radiation equipment	☐		☐	
Toxic chemical storage				
_____	☐	☐	☐	
_____	☐	☐	☐	
_____	☐	☐	☐	
_____	☐	☐	☐	
Liquid oxygen tanks	☐	☐	☐	
Other: _____	☐	☐	☐	
_____	☐	☐	☐	

Recommendations/Comments: _____

Figure 13-1 Fixed equipment checklist for essential facilities. This form may be downloaded at ***www.atcouncil.org***

Table 13-1. Operability and Safety Considerations for Fixed Equipment

Item	Principal Concerns
Main boilers	Sliding, broken gas/fuel lines, broken exhaust lines, broken/bent steam and relief lines
Chillers	Sliding, loss of function, leaking refrigerant
Emergency generators	Failed vibration isolation mounts; sliding; broken fuel, cooling, signal, and power lines, leading to loss of function; broken exhaust lines
Fuel tanks	Sliding or overturning, leaks, broken fuel lines
Battery racks	Damaged rack, dislodged batteries, acid spill
Fire pumps	Anchorage failure, misalignment between pump and motor, broken piping
On-site water storage	Tank or vessel rupture, pipe break
Communications equipment	Sliding, overturning, or toppling, leading to loss of function
Main transformers	Sliding, oil leak, loss of function
Main electrical panels	Sliding or overturning, broken or damaged conduit or electrical bus
Elevators (traction)	Counterweights out of guide rails, cables out of sheaves, dislodged equipment
Other fixed equipment	Sliding or overturning, leading to loss of function (or damage to adjacent equipment)
Special Concerns for Hospitals and Other Health Care Facilities	
Radiation charges	Breach of containment, cobalt contamination
Toxics and chemicals	Spill, fumes in ventilation system
Liquid oxygen tanks	Sliding or overturning, leaks, broken lines

Appendix A. California OES Volunteer Engineer Program

The California Governor's Office of Emergency Services (OES) has a program to use engineers, architects, and building inspectors from the private and public sectors to assist local government in evaluating the safety of structures following a disaster. Private sector professional organizations maintain rosters of qualified and trained individuals who are registered by OES as Disaster Service Workers and volunteer to spend three days evaluating structures when the need arises. Public sector individuals are registered and trained through the California Building Officials (CALBO) and are available to local government through mutual aid channels.

Liability Issues

Liability protection is available to all who respond. For the public-sector individuals, their liability protection is provided by their home jurisdiction and by the receiving jurisdiction once they are deputized. When deputized, they are official representatives of the jurisdiction and receive all the liability protections available to the jurisdiction. Private-sector individuals receive their protection from several sources listed below.

- California's Good Samaritan Law provides general immunity for anyone helping during a situation.
- The *California Emergency Services Act*, Section 8657 applies.
- For licensed architects and registered engineers the *State of California Business and Professions Code*, Chapter 30, Section 5536.27 applies for architects and Section 6706 applies for engineers.
- Once deputized by the receiving jurisdiction, private-sector individuals have the same liability protection as any other member of the jurisdiction.

Workers' Compensation

Public-sector individuals are covered by their home jurisdiction. State agency personnel receive their coverage through the state. Private-sector individuals receive their coverage through the California Emergency Services Act, Section 8580. However, for private-sector individuals to receive Workers' Compensation coverage, they must not receive any kind of payment from anyone during their response.

Appendix B. Human Factors Following Earthquakes

Dealing With Occupants And Owners of Damaged Property

Remembering these tips may pave the way for quicker inspections.

1. Owners and occupants of damaged property may contact you in need of "hand holding." Homeowners may want someone of authority to reassure them that their home is safe.
2. There may be owners or occupants who are suspicious and reluctant to cooperate. These individuals should be dealt with in an objective, factual, and patient manner. If there is reason to believe that the structure may have suffered damage and entry to the structure is refused, the building should be appropriately posted and the authorities contacted.
3. When it is necessary to post a building Unsafe, the reasons for this (e.g., collapse hazard) should be explained to those affected.
4. People may also be seeking help when they contact the inspector in the field. Be prepared to direct victims to help facilities, such as emergency shelters and Red Cross field stations.

The ATC-20-2 report (ATC, 1995) contains detailed guidance to answer many of the typical questions that arise during the postearthquake recovery period. The issues covered include (1) the safety evaluation process and the meaning of each of the three safety evaluation placards; (2) the process of securing services to perform repairs; and (3) how to obtain aid from disaster assistance organizations. A handout containing this guidance is available at *www.atcouncil.org* (see Appendix F).

Coping With Stress In The Field

Postearthquake building safety evaluation can be grueling work. Unchecked overwork can often lead to "burn-out." To forestall this, take the stress-relieving measures listed below.

1. Develop a buddy system with a co-worker. Keep an eye on each other.
2. Encourage and support co-workers.
3. Talk about your feelings, experiences, and fears, and listen to those around you.
4. Exercise or enjoy some recreation away from the disaster scene.
5. Eat well and get enough sleep (i.e., 12 hours on and 12 off).
6. Pace yourself.
7. Take breaks if your effectiveness is diminishing.

Acknowledging that you are in a stressful situation and taking steps to relieve some of that stress is the best way to perform well under the pressure of the disaster situation.

Appendix C. Field Safety

Safety In The Field

Following a severe seismic disturbance, many buildings become so heavily damaged that the danger from collapse or falling debris can be quite high, particularly when strong aftershocks occur. Consequently, inspectors must be conscious of their own safety and that of their team members at all times. To protect yourself and your team members, remember the safety tips given in Table C-1.

Table C-1. Field Safety Tips

1. Travel in teams of at least two people.
2. Wear a hard hat for safety and identification.
3. Survey the building exterior completely before entering.
4. Enter a building only if it is deemed safe to do so.
5. Avoid all areas where a hazardous material release is suspected or confirmed.
6. Use available safety equipment when appropriate.
7. Be alert for falling hzards.
8. In case of fire, evacuate the area and alert the fire department immediately.
9. Avoid downed power lines and buildings under them.
10. In case of gas leaks, shut off the gas (if possible) and report the leak.
11. Be alert for people unlawfully occupying vacant buildings.

Hazardous Materials

Hazardous materials are very prevalent in today's society. Most commercial chemicals are marked for identification and safety purposes (Figure C-1). In most communities, the fire department is assigned the respousibility for maintaining information on hazard-

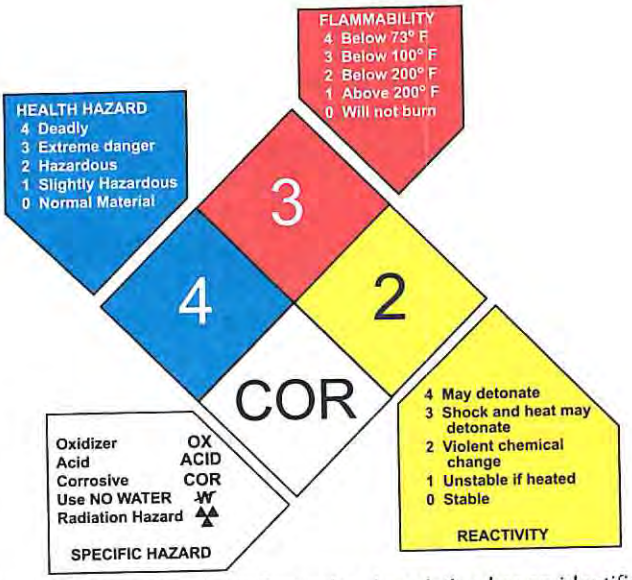


Figure C-1 The National Fire Protection Association has an identification system for hazardous materials. The sign shown above indicates health hazards (left), flammability (top), reactivity (right), and specific hazard (e.g., reactivity to water) (bottom) for one specific chemical. Hazards are rated from 0 (lowest) to 4 (highest and most dangerous).

ous materials stored in the area. Try to obtain this information before beginning an inspection.

Sites that have potential spills should be approached from upwind. If a spill is suspected, do not approach.

Recognition of hazardous materials

1. The type of facility (e.g., building used for chemical storage, industrial plant, laboratory) is often an indicator of whether hazardous substances may be found.

2. Clues to possible hazardous material spills include:
   - breached container,
   - obvious solid or liquid spill,
   - unique odors, strange noises, or physical reactions (e.g., nausea, dizziness, eye/skin irritation, dead animals), and
   - pipeline rupture.
3. Damaged fireproofing or broken insulation on pipes and around boilers in older buildings may indicate release of friable asbestos.

Actions to be taken when hazardous materials are found

1. Leave, seal off, if possible, and post any area where a chemical spill or asbestos contamination is suspected.
2. Notify the local jurisdiction. If possible, make note of the chemical name or any markings on the container.

Field Equipment

Safe and successful inspections require that inspectors be properly equipped. Table C-2 lists what each team of inspectors is expected to carry. Some of these items must be furnished by the local building department. Special circumstances and personal preferences may dictate other choices. ATC-20 provides a comprehensive listing of both personal and field office equipment.

Minimizing Risks

It is strongly recommended that persons entering severely damaged buildings do so only for emergency reasons and take safety precautions, including wearing a hard hat and strong shoes, carrying a flashlight, and exercising extreme care. Entry into seriously damaged buildings is never risk-free. Appendix D provides entry guidelines.

Table C-2. Equipment and Other Items Normally Carried by the Inspector

Personal identification/driver's license.
Official identification
Change for pay phones
Safety glasses
Hard hat
Dust mask
Clipboard/notebook
Pens/pencils
Flashlight
Cell phone/portable radio[a,b]
Street maps[a,b]
Inspections forms[a]
Posting placards[a]
Yellow "caution" tape[a]
Staple gun/thumbtacks or tape for placards[a,b]
Emergency phone numbers[a]
Rain gear
ATC-20-1 Field Manual
Informational handouts[a,b]
Level and tape measure

a. Normally furnished by local building department.
b. Carried by one team member.

Appendix D. Entry into Damaged Buildings

Aftershocks

Entry into damaged buildings soon after an earthquake is necessary for a variety of reasons, including search and rescue, building stabilization and repair, and salvage and retrieval of possessions. Aftershocks are common in days following a large earthquake, and they can create new falling hazards or lead to partial or complete collapse of previously damaged buildings. Because people entering damaged buildings are at risk, the decision to permit entry must consider both the level of initial damage and the probability of damaging aftershocks.

Aftershocks of magnitude 5 and larger are generally considered most likely to cause significant damage or to worsen existing damage. Since the chances of a strong aftershock diminish with time, entering damaged buildings is safer the longer one waits after the earthquake. The entry guidelines given in this Appendix are based on the ATC TechBrief 2 "Earthquake Aftershocks—Entering Damaged Buildings." This document estimated the probability of a magnitude 5 or greater aftershock occuring during the time a damaged building is occupied, as a function of the size of the mainshock, the time elapsed since the mainshock, and the duration of occupancy.

Entry Guidelines

Table D-1 provides recommended guidelines for emergency entry into damaged buildings. For buildings posted Unsafe, entry depends on whether the building is considered ***stable*** or ***unstable***. Guidelines for classifying a building as unstable are provided in Table D-2 and in "Examples of Stable and Unstable Structures" on page 109. Table D-3 provides guidelines on how long to wait before entering buildings that are classified as Unsafe but stable. The risk associated with building entry after these wait times corresponds roughly to the risk firefighters assume when fighting structural fires.

Table D-1. Guidelines for Emergency Entry of Damaged Building

Posting	Condition	Entry Allowed[a]
None (not yet inspected)	Serious structural damage	Only for search and rescue, and at own risk.
Inspected	Minor structural damage	Yes.
Restricted Use	Some structural damage, generally of limited severity	Yes, but according to restrictions. Entry into the restricted area only with permission of the local building department.
Unsafe	Structure has serious structural damage, but is **stable**	Yes, according to Table D-3 guidelines.
Unsafe	Structure has serious structural damage and is **unstable**	No. Table D-3 does not apply. Entry only with written permission of the local building department.
Unsafe	Posting due to other than structural damage	No. Table D-3 does not apply. Entry only with written permission of the local building department.

a. During the first 24 hours, entry into seriously damaged buildings should be avoided in case the damaging shock is a foreshock and a subsequent event is the mainshock.

Table D-2. Guidelines for Classifying Damaged Buildings as Unstable

Unsafe buildings that have at least one of the following characteristics should be classified as unstable:

1. May collapse or partially collapse under its own weight.
2. Likely to collapse in a strong aftershock, from additional damage.
3. Ongoing, progressive lean.
4. Ongoing creep or structural deterioration.
5. So heavily damaged that its stability cannot readily be determined.

Table D-3. Recommended Days to Wait Before Entry of Buildings Posted Unsafe, but Stable[a,b]

Mainshock Magnitude (*M*)	Enter for 2 hours	Enter for 8 hours	Enter for 24 hours[c]
M equal to 6.5 or greater	1 day	3 days	8 days
M equal to 6.0 or greater, but less than 6.5	1 day	2 days	4 days
M less than 6.0	1 day	1 day	2 days

a. Refer to Table D-1 for other posting conditions.
b. Recommended days to wait refers to the date of the mainshock, not the date of posting.
c. For continuous access only by essential personnel and repair workers. Full-time occupancy is permitted only when approved by the local building department.

Search and Rescue

Table D-3 is not intended to apply to search and rescue operations. Search and rescue personnel, by nature, take higher risks.

Minimizing Risks

It is strongly recommended that persons entering severely damaged buildings do so only for emergency reasons and take safety precautions, including wearing a hard hat and strong shoes, carrying a flashlight, and exercising extreme care. *Entry into seriously damaged buildings is never risk-free.*

Examples of Stable and Unstable Structures

A stable structure (see Figures D-1 and D-2) is not expected to collapse or partially collapse under its own weight or in an aftershock. Stable structures may, however, sustain additional damage in an aftershock. An unstable structure (see Figures D-3 through D-7) is one that is very hazardous and may collapse or partially collapse at any time, particularly in an aftershock.

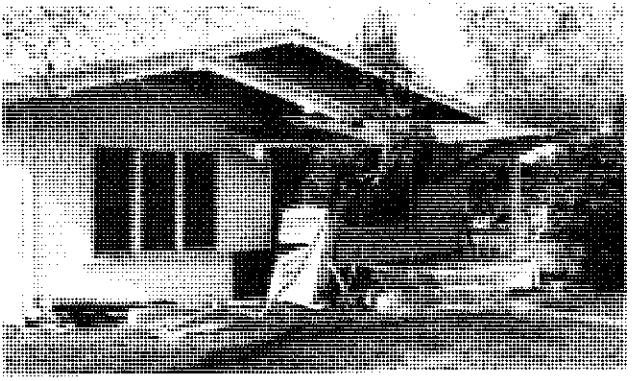


Figure D-1 This Sylmar, California house has moved off its foundations and is resting on the ground. It is considered a ***stable*** Unsafe structure because further collapse is prevented by the first-floor walls. Emergency entry is permitted according to Table D-3.

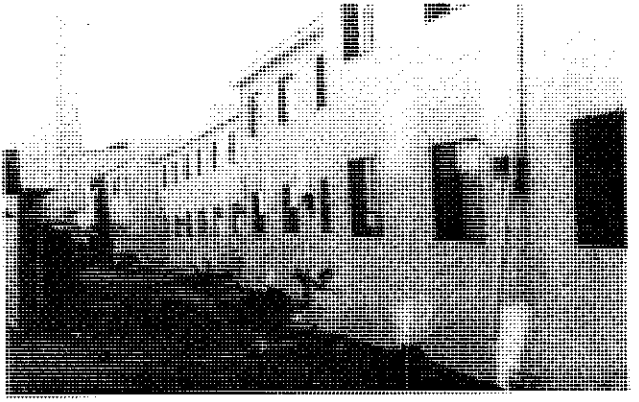


Figure D-2 The first story of this apartment building collapsed, crushing cars parked at the ground level. Because the upper two floors of this wood-frame building are intact, it is unlikely to collapse further and is considered a ***stable*** Unsafe structure. Emergency entry is permitted according to Table D-3.

Figure D-3 This office building in Kobe, Japan, is considered an ***unstable*** Unsafe structure because it could easily collapse in an after-shock. Entry is not allowed.

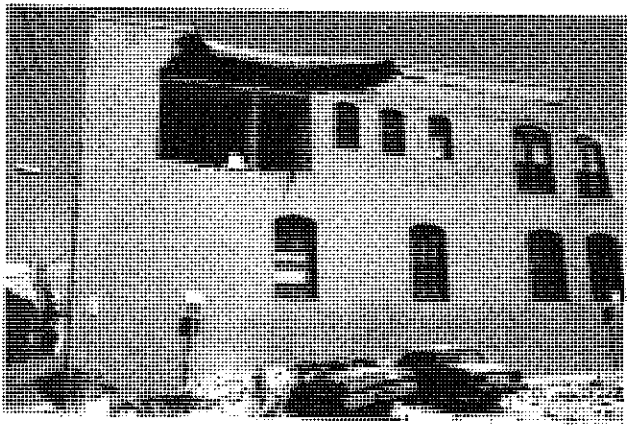


Figure D-4 This is a severely damaged URM building. The top portion of the wall at the right is an imminent collapse hazard. This building is considered an ***unstable*** Unsafe structure, and entry is not allowed.

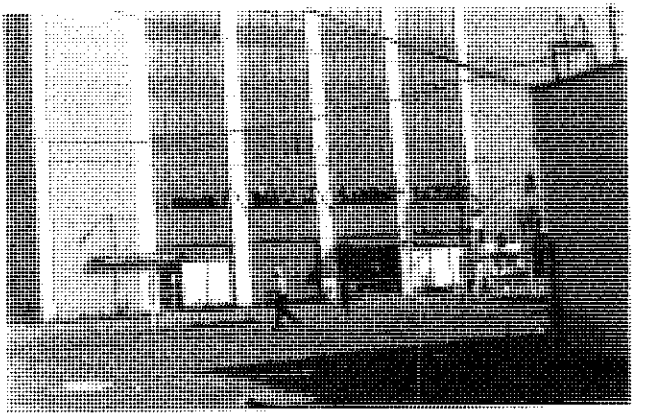


Figure D-5 This six-story nonductile concrete building has severe column damage at the second floor. It is an ***unstable*** Unsafe building because the columns can give way at any time. Entry is not permitted.

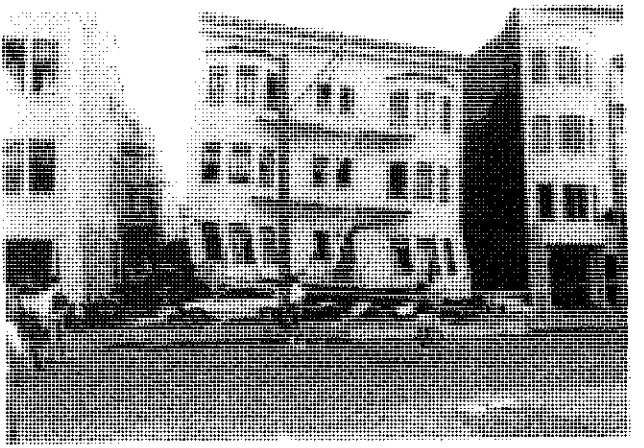


Figure D-6 A collapsed San Francisco, California apartment building. Because of the extent of damage at the first floor, the building is considered an ***unstable*** Unsafe structure, and entry is not allowed.

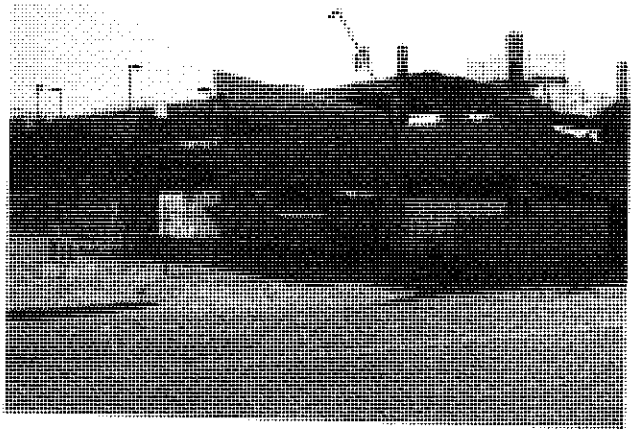


Figure D-7 This Northridge, California, parking structure has been very heavily damaged and is considered an ***unstable*** Unsafe structure. Entry is not allowed.

Appendix E. Examples

Example 1—Rapid Evaluation with Unsafe Posting

Scenario

A small community was hit by a magnitude 6.1 earthquake. Rapid Evaluation is being done on a dwelling in the hardest-hit residential area.

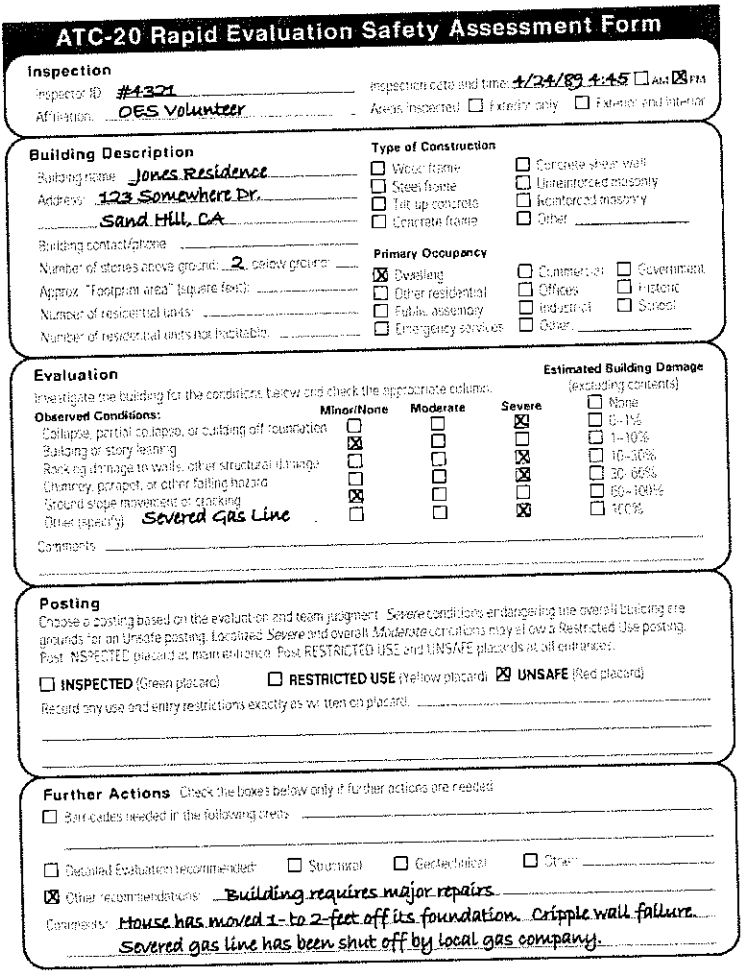
Safety Evaluation

A two-story wood-frame dwelling (Figure E-1) has sustained a cripple-wall failure and has moved one to two feet laterally on its foundations. A strong natural gas odor is present, and investigation reveals a severed gas line (it was subsequently learned that the local gas company had already shut off the gas). No permanent ground movements are observed in the immediate vicinity of the structure. The completed Rapid Evaluation safety assessment form and posting placard for this structure are shown in Figures E-2 and E-3, respectively.

Summary of Required Action

1. Post the building Unsafe.
2. Request that all utility services to the building be disconnected (the gas has already been shut-off).

Figure E-1 Dwelling of Example 1.



ATC-20 Rapid Evaluation Safety Assessment Form

Inspection

Inspector ID: #1321
Affiliation: OES Volunteer
Inspection date and time: 4/24/89 1:45 ☐ AM ☒ PM
Areas inspected: ☐ Exterior only ☐ Exterior and interior

Building Description

Building name: Jones Residence
Address: 123 Somewhere Dr.
Sand Hill, CA
Building contact/phone:
Number of stories above ground: 2 below ground:
Approx. "footprint area" (square feet):
Number of residential units:
Number of residential units not habitable:

Type of Construction

☐ Wood frame ☐ Concrete shear wall
☐ Steel frame ☐ Unreinforced masonry
☐ Tilt-up concrete ☐ Reinforced masonry
☐ Concrete frame ☐ Other

Primary Occupancy

☒ Dwelling ☐ Commercial ☐ Government
☐ Other residential ☐ Offices ☐ Historic
☐ Public assembly ☐ Industrial ☐ School
☐ Emergency services ☐ Other

Evaluation

Investigate the building for the conditions listed below and check the appropriate column.

Observed Conditions:	Minor/None	Moderate	Severe	Estimated Building Damage (excluding contents)
Collapse, partial collapse, or sliding off foundation	☐	☐	☒	☐ None
Building or story leaning	☒	☐	☐	☐ 0–1%
Racking damage to walls, other structural damage	☐	☐	☒	☐ 1–10%
Chimney, parapet, or other falling hazard	☐	☐	☒	☐ 10–30%
Ground slope movement or cracking	☒	☐	☐	☐ 30–65%
(Other (specify) Severed Gas Line	☐	☐	☒	☐ 65–100%
				☐ 100%

Comments:

Posting

Choose a posting based on the evaluation and team judgment. *Severe* conditions endangering the overall building are grounds for an Unsafe posting. Localized *Severe* and overall *Moderate* conditions may allow a Restricted Use posting. Post INSPECTED placard at main entrance. Post RESTRICTED USE and UNSAFE placards at all entrances.

☐ **INSPECTED** (Green placard) ☐ **RESTRICTED USE** (Yellow placard) ☒ **UNSAFE** (Red placard)

Record any use and entry restrictions exactly as written on placard:

Further Actions Check the boxes below only if further actions are needed.

☐ Barricades needed in the following areas:

☐ Detailed Evaluation recommended: ☐ Structural ☐ Geotechnical ☐ Other:

☒ Other recommendations: Building requires major repairs.

Comments: House has moved 1- to 2-feet off its foundation. Cripple wall failure. Severed gas line has been shut off by local gas company.

Figure E-2 Completed Rapid Evaluation form for Example 1.

UNSAFE

DO NOT ENTER OR OCCUPY
(THIS PLACARD IS NOT A DEMOLITION ORDER)

This structure has been inspected, found to be seriously damaged and is unsafe to occupy, as described below:

DWELLING OFF FOUNDATION
SEVERED GAS LINE

Do not enter, except as specifically authorized in writing by jurisdiction. Entry may result in death or injury.

Facility Name and Address:

JONES RESIDENCE
123 SOMEWHERE DR.
SAND HILL, CA

Date 4/24/89

Time 4:45 PM

This facility was inspected under emergency conditions for:

SAND HILL BUILDING DEPARTMENT
(Jurisdiction)

Inspector ID / Agency

#1321
OES VOLUNTEER

Do Not Remove, Alter, or Cover this Placard until Authorized by Governing Authority

Figure E-3 Completed Posting Placard for Example 1.

Example 2—Detailed Evaluation with Inspected Posting

Scenario

A magnitude 6.5 earthquake has struck. A team of building inspectors doing a Rapid Evaluation of buildings in the area wants a Detailed Evaluation of a high-rise building with what they describe as a large crack in its exterior concrete frame.

Safety Evaluation

The building (Figure E-4) is a seven-story concrete structure with a moment frame at its perimeter and an interior flat-slab system without drop panels. An observation of the outside of the building reveals no evidence of ground failures. There are no cracks in the sidewalks or streets and the building does not lean in any direction.

Figure E-4 Building of Example 2.

On the exterior of the building, there are some cracks above the doorways that were not there before the earthquake, but there are no large X-cracks in the plaster walls. Further reconnaissance around the outside of the building reveals that windows were not broken, but there are definite signs of damage to concrete mullions (Figure E-5). There is some minor spalling. Examination of the joint between a reinforced concrete beam and column reveals a fairly good-sized crack (Figure E-6), but there is no massive spalling, and no reinforcement is showing.

Figure E-5 Spalling at mullion, Example 2.

Inspection on the interior of the building reveals a fair amount of racking damage to walls and partitions, such as cracked and broken tile in the bathrooms. Examination of concrete beams and columns that are visible in the stairways reveals that they have cracked (Figure E-7), and, although the cracks are easily visible, there seems to be neither any spalling nor any sign of major structural damage. No reinforcement is showing. Examination of slabs in the vicinity of colnmns reveals no cracking.

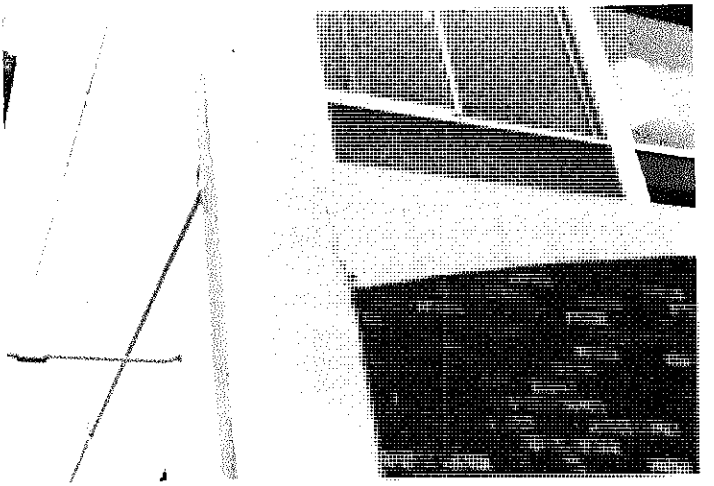


Figure E-6 Beam crack at second level, Example 2.

Figure E-7 Typical cracking in perimeter moment frame, Example 2.

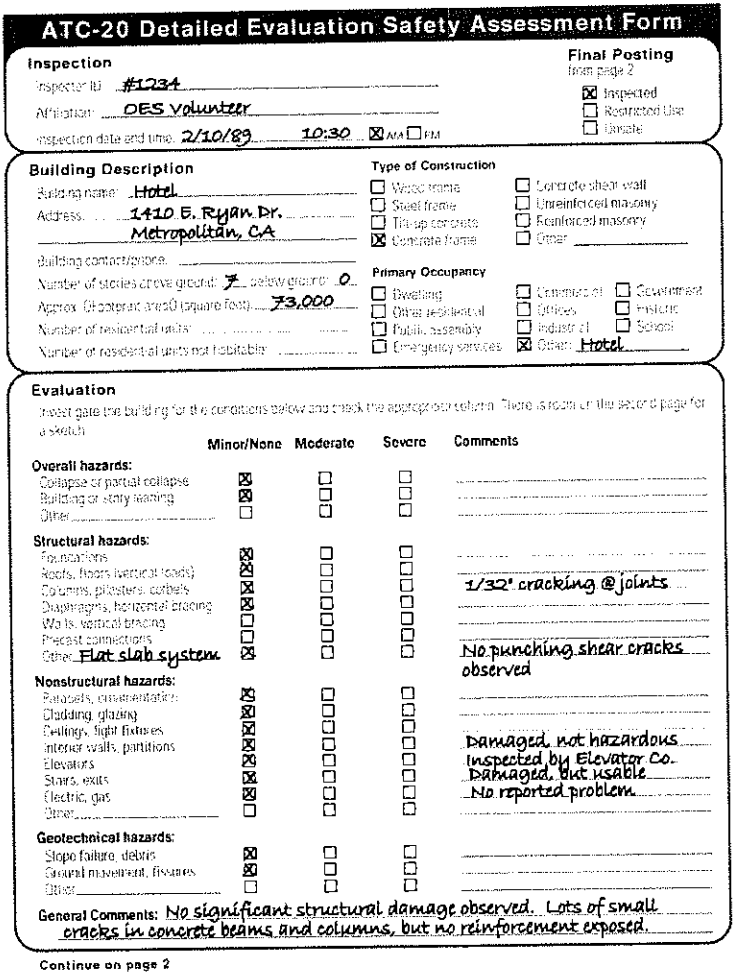
In general, things look pretty good. There is a lack of significant structural damage. The completed Detailed Evaluation form and posting placard for this structure are given in Figures E-8 and E-9, respectively.

Summary of Required Action

1. Post the building Inspected.

Commentary

The damage to this building shown in this example occurred during the 1971 San Fernando earthquake. Much more serious damage to the structure occurred during the 1994 Northridge earthquake (see Example 4). This was due to much stronger ground shaking at the site in 1994.



ATC-20 Detailed Evaluation Safety Assessment Form

Inspection

Inspector ID: #1234

Affiliation: OES Volunteer

Inspection date and time: 2/10/89 10:30 ☒ AM ☐ PM

Final Posting (from page 2)

☒ Inspected
☐ Restricted Use
☐ Unsafe

Building Description

Building name: Hotel

Address: 1410 E. Ryan Dr.
Metropolitan, CA

Building contact/phone:

Number of stories above ground: 7 below ground: 0

Approx. GFA (square feet): 73,000

Number of residential units:

Number of residential units not habitable:

Type of Construction

☐ Wood frame
☐ Steel frame
☐ Tilt-up concrete
☒ Concrete frame
☐ Concrete shear wall
☐ Unreinforced masonry
☐ Reinforced masonry
☐ Other:

Primary Occupancy

☐ Dwelling
☐ Other residential
☐ Public assembly
☐ Emergency services
☐ Commercial
☐ Offices
☐ Industrial
☒ Other: Hotel
☐ Government
☐ Historic
☐ School

Evaluation

Inspect gate the building for the conditions below and check the appropriate column. There is room on the second page for a sketch.

	Minor/None	Moderate	Severe	Comments
Overall hazards:				
Collapse or partial collapse	☒	☐	☐	
Building or story leaning	☒	☐	☐	
Other	☐	☐	☐	
Structural hazards:				
Foundations	☒	☐	☐	
Roofs, floors (vertical loads)	☒	☐	☐	
Columns, pilasters, corbels	☒	☐	☐	1/32" cracking @ joints
Diaphragms, horizontal bracing	☒	☐	☐	
Walls, vertical bracing	☐	☐	☐	
Precast connections	☐	☐	☐	
Other: Flat slab system	☒	☐	☐	No punching shear cracks observed
Nonstructural hazards:				
Parapets, ornamentation	☒	☐	☐	
Cladding, glazing	☒	☐	☐	
Ceilings, light fixtures	☒	☐	☐	
Interior walls, partitions	☒	☐	☐	Damaged, not hazardous
Elevators	☒	☐	☐	Inspected by Elevator Co.
Stairs, exits	☒	☐	☐	Damaged, but usable
Electric, gas	☒	☐	☐	No reported problem
Other	☐	☐	☐	
Geotechnical hazards:				
Slope failure, debris	☒	☐	☐	
Ground movement, fissures	☒	☐	☐	
Other	☐	☐	☐	

General Comments: No significant structural damage observed. Lots of small cracks in concrete beams and columns, but no reinforcement exposed.

Continue on page 2

Figure E-8 Completed Detailed Evaluation form for Example 2.

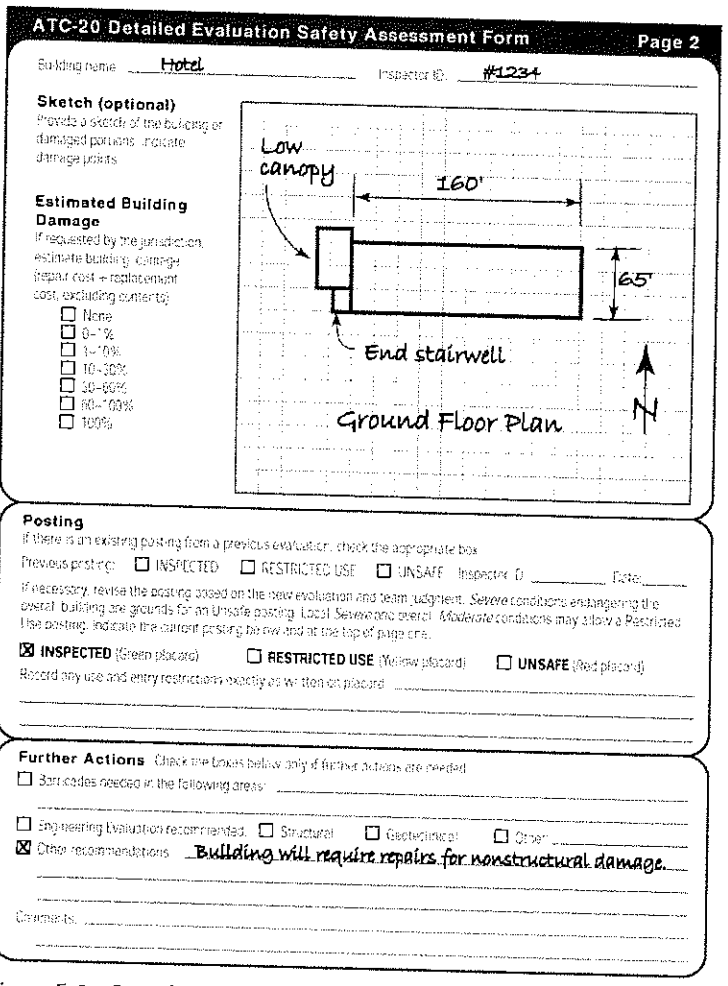


Figure E-8 Completed Detailed Evaluation form for Example 2. (Continued)

INSPECTED

LAWFUL OCCUPANCY PERMITTED

This structure has been inspected (as indicated below) and no apparent structural hazard has been found.

☐ **Inspected Exterior Only**

☒ **Inspected Exterior and Interior**

Report any unsafe condition to local authorities; reinspection may be required.

Inspector Comments:

Facility Name and Address:
HOTEL
1410 E. RYAN DR.
METROPOLITAN, CA

Date 2/10/89

Time 10:30 AM

(**Caution:** Aftershocks since inspection may increase damage and risk.)

This facility was inspected under emergency conditions for:
METROPOLITAN BUILDING DEPARTMENT
(Jurisdiction)

Inspector ID / Agency
#1234
OES VOLUNTEER

Do Not Remove, Alter, or Cover this Placard until Authorized by Governing Authority

Figure E-9 Completed posting placard for Example 2.

Example 3—Rapid Evaluation with Restricted Use Posting

Scenario

Rapid Evaluation is being done in a residential area. A relatively new home (estimated to be about 10 to 20 years old) experienced severe chimney damage in the magnitude 5.8 earthquake. A view of the house from the street is shown in Figure E-10 and a close-up of the damaged chimney is shown in Figure E-11.

Safety Evaluation

Inspection reveals that the home was essentially undamaged except for the chimney. Although the home is located on a hillside, there are no signs of any ground movements in the vicinity. The sidewalk and pavement show no new cracks.

Since the home is undamaged except for the broken chimney, the principal safety concerns are fire and falling hazards. The house should be posted Restricted Use, and the placard annotated to warn the owner not to use the fireplace. The portion of the chimney above the roof may fall (either of its own accord or due to an aftershock), and the potential impact area between houses must be barricaded to prevent entry. (Note: If the adjacent house can be struck by the falling chimney, it must also be posted Restricted Use.)

The completed Rapid Evaluation assessment form and RESTRICTED USE placard are shown in Figures E-12 and E-13.

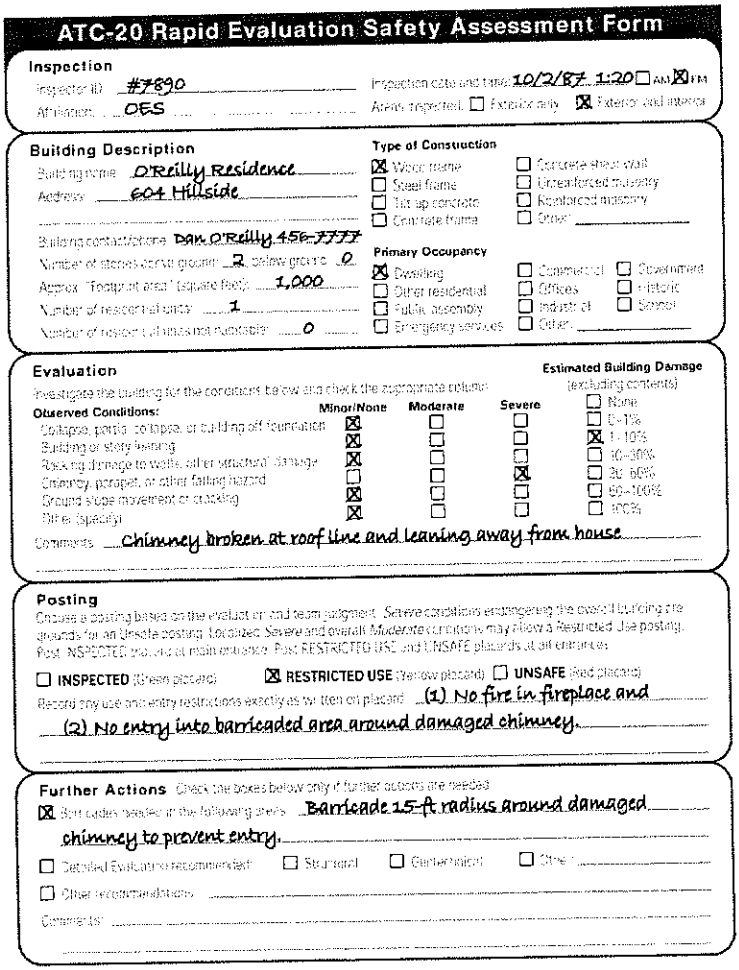
Summary of Required Action

1. Post the building Restricted Use with restrictions of "No fire in fireplace" and "No entry into barricaded area around damaged chimney."

2. Using caution tape, barricade the fireplace and the area on exterior of the house where the chimney could impact if it fell.
3. Advise the owner not to use the fireplace.

Figure E-10 The home with the leaning chimney from Example 3 is shown on the right.

Figure E-11 This leaning chimney from Example 3 has been severely damaged and presents a serious falling hazard. (Note: In some cases, chimneys may be in danger of falling through the roof into the dwelling. In such cases, interior spaces should be barricaded.)



ATC-20 Rapid Evaluation Safety Assessment Form

Inspection

Inspector ID: #7890 — Inspection date and time: 10/2/87 1:20 ☐ AM ☒ PM

Affiliation: OES — Areas inspected: ☐ Exterior only ☒ Exterior and interior

Building Description

Building name: O'Reilly Residence

Address: 604 Hillside

Building contact/phone: Dan O'Reilly 456-7777

Number of stories above ground: 2 — below grade: 0

Approx. footprint area (square feet): 1,000

Number of residential units: 1

Number of nonresidential units and function: 0

Type of Construction

☒ Wood frame — ☐ Concrete shear wall
☐ Steel frame — ☐ Unreinforced masonry
☐ Tilt-up concrete — ☐ Reinforced masonry
☐ Concrete frame — ☐ Other: _____

Primary Occupancy

☒ Dwelling — ☐ Commercial — ☐ Government
☐ Other residential — ☐ Offices — ☐ Historic
☐ Public assembly — ☐ Industrial — ☐ School
☐ Emergency services — ☐ Other: _____

Evaluation

Investigate the building for the conditions below and check the appropriate column.

Observed Conditions:	Minor/None	Moderate	Severe
Collapse, partial collapse, or building off foundation	☒	☐	☐
Building or story leaning	☒	☐	☐
Racking damage to walls, other structural damage	☒	☐	☐
Chimney, parapet, or other falling hazard	☐	☐	☒
Ground slope movement or cracking	☒	☐	☐
Other (specify):	☒	☐	☐

Estimated Building Damage (excluding contents)

☐ None
☐ 0–1%
☒ 1–10%
☐ 10–30%
☐ 30–60%
☐ 60–100%
☐ 100%

Comments: Chimney broken at roof line and leaning away from house

Posting

Choose a posting based on the evaluation and team judgment. *Severe* conditions endangering the overall building are grounds for an UNSAFE posting. Localized *Severe* and overall *Moderate* conditions may allow a RESTRICTED USE posting. Post INSPECTED placard at main entrance. Post RESTRICTED USE and UNSAFE placards at all entrances.

☐ **INSPECTED** (Green placard) ☒ **RESTRICTED USE** (Yellow placard) ☐ **UNSAFE** (Red placard)

Record any use and entry restrictions exactly as written on placard: (1) No fire in fireplace and (2) No entry into barricaded area around damaged chimney.

Further Actions Check the boxes below only if further actions are needed.

☒ Bar codes needed in the following areas: Barricade 15-ft radius around damaged chimney to prevent entry.

☐ Detailed Evaluation recommended ☐ Structural ☐ Geotechnical ☐ Other: _____

☐ Other recommendations: _____

Comments: _____

Figure E-12 Completed Rapid Evaluation assessment form for Example 3.

RESTRICTED USE

Caution: This structure has been inspected and found to be damaged as described below:

CHIMNEY BROKEN AT ROOF LINE AND LEANING AWAY FROM HOUSE

Entry, occupancy, and lawful use are restricted as indicated below:

(1) NO FIRE IN FIREPLACE
(2) NO ENTRY INTO BARRICADED AREA AROUND DAMAGED CHIMNEY

Facility Name and Address:

O'REILLY RESIDENCE
604 HILLSIDE

Date 10/2/87

Time 1:20 PM

(**Caution:** Aftershocks since inspection may increase damage and risk.)

This facility was inspected under emergency conditions for:

WHITTIER
(Jurisdiction)

Inspector ID / Agency

#7890
OES

Do Not Remove, Alter, or Cover this Placard until Authorized by Governing Authority

Figure E-13 RESTRICTED USE placard for Example 3.

Example 4—Detailed Evaluation with Unsafe Posting

Scenario

The seven-story hotel shown in Figures E-14 and E-15 was shaken by a very strong earthquake. After an initial Rapid Evaluation, the local jurisdiction has requested a Detailed Evaluation to confirm the initial Unsafe posting.

Safety Evaluation

The building is a reinforced concrete structure with exposed concrete frames on its north and south sides. It is not leaning, but there is extensive cracking of concrete columns. On the south side just below the fifth floor (see Figure E-16), the concrete columns have experienced severe fractures, as shown in Figure E-17. Several of these columns have essentially lost their capacity to carry vertical load. The structure has been so seriously damaged that it may collapse in an aftershock.

This building must be posted Unsafe, and guests cannot be allowed to enter the building to retrieve belongings. The completed Detailed Evaluation assessment form and UNSAFE placard are given in Figures E-18 and E-19, respectively.

Summary of Required Action

1. Post the building Unsafe.
2. Barricade 75 feet out all around the building.
3. Request that the utility service to the building be disconnected.
4. Advise the manager that any remaining occupants should leave the building immediately.
5. Report to your supervisor that the building is a potential collapse hazard.

Commentary

This building survived the 1971 San Fernando earthquake with only minor structural damage. It is used in herein to illustrate the Detailed Evaluation method (Example 2). During the 1994 Northridge earthquake, much stronger ground motions caused the much greater damage and near-collapse of the building.

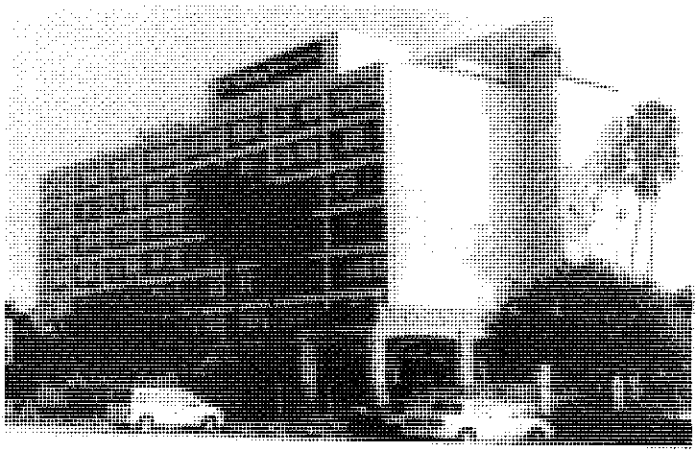
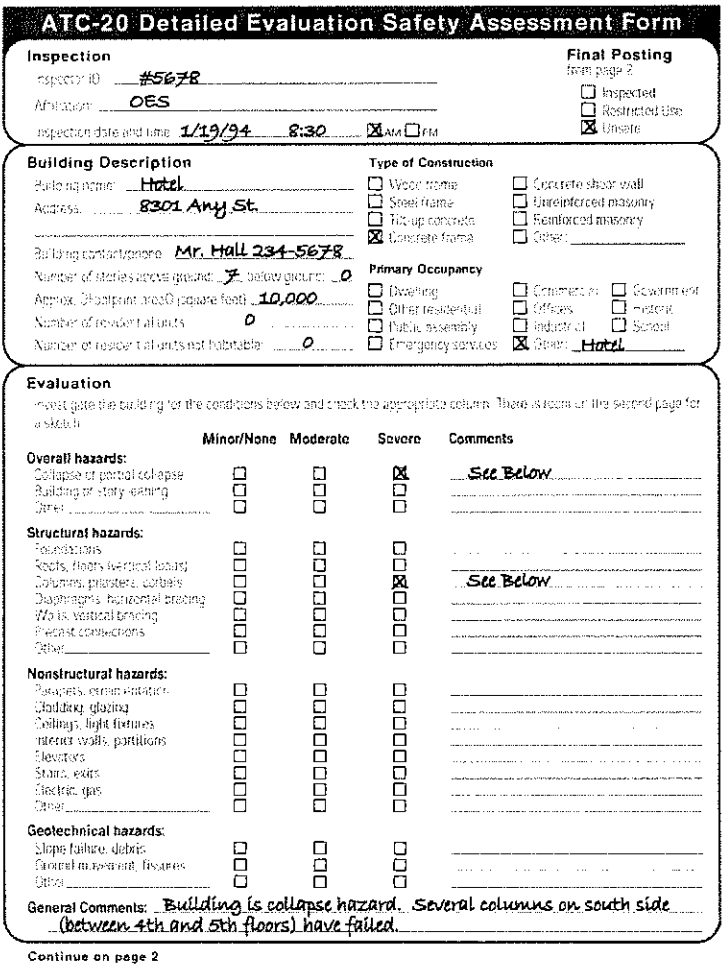


Figure E-14 Seven-story Los Angeles hotel of Example 4 damaged in the 1994 Northridge earthquake.

Figure E-15 South side of the hotel from Example 4.

Figure E-16 Columns between the fourth and fifth floors are fractured, Example 4.

Figure E-17 Close-up of fractured column from Example 4. This column, which lacks confinement of the vertical reinforcement, has essentially lost its capacity to carry a vertical load.



ATC-20 Detailed Evaluation Safety Assessment Form

Inspection

Inspector ID: #5678

Affiliation: OES

Inspection date and time: 1/19/94 8:30 ☒ AM ☐ PM

Final Posting (from page 2)

☐ Inspected
☐ Restricted Use
☒ Unsafe

Building Description

Building name: Hotel

Address: 8301 Any St.

Building contact/phone: Mr. Hall 234-5678

Number of stories above ground: 7 below ground: 0

Approx. floor area (square feet): 10,000

Number of residential units: 0

Number of residential units not habitable: 0

Type of Construction

☐ Wood frame
☐ Steel frame
☐ Tilt-up concrete
☒ Concrete frame
☐ Concrete shear wall
☐ Unreinforced masonry
☐ Reinforced masonry
☐ Other: _____

Primary Occupancy

☐ Dwelling
☐ Other residential
☐ Public assembly
☐ Emergency services
☐ Commercial
☐ Offices
☐ Industrial
☐ Government
☐ Historic
☐ School
☒ Other: Hotel

Evaluation

Inspect the building for the conditions below and check the appropriate column. There is room on the second page for a sketch.

	Minor/None	Moderate	Severe	Comments
Overall hazards:				
Collapse or partial collapse	☐	☐	☒	See Below
Building or story leaning	☐	☐	☐	
Other:	☐	☐	☐	
Structural hazards:				
Foundations	☐	☐	☐	
Roofs, floors (vertical loads)	☐	☐	☐	
Columns, pilasters, corbels	☐	☐	☒	See Below
Diaphragms, horizontal bracing	☐	☐	☐	
Walls, vertical bracing	☐	☐	☐	
Precast connections	☐	☐	☐	
Other:	☐	☐	☐	
Nonstructural hazards:				
Parapets, ornamentation	☐	☐	☐	
Cladding, glazing	☐	☐	☐	
Ceilings, light fixtures	☐	☐	☐	
Interior walls, partitions	☐	☐	☐	
Elevators	☐	☐	☐	
Stairs, exits	☐	☐	☐	
Electrical, gas	☐	☐	☐	
Other:	☐	☐	☐	
Geotechnical hazards:				
Slope failure, debris	☐	☐	☐	
Ground movement, fissures	☐	☐	☐	
Other:	☐	☐	☐	

General Comments: Building is collapse hazard. Several columns on south side (between 4th and 5th floors) have failed.

Continue on page 2

Figure E-18 Completed Detailed Evaluation assessment form for Example 4.

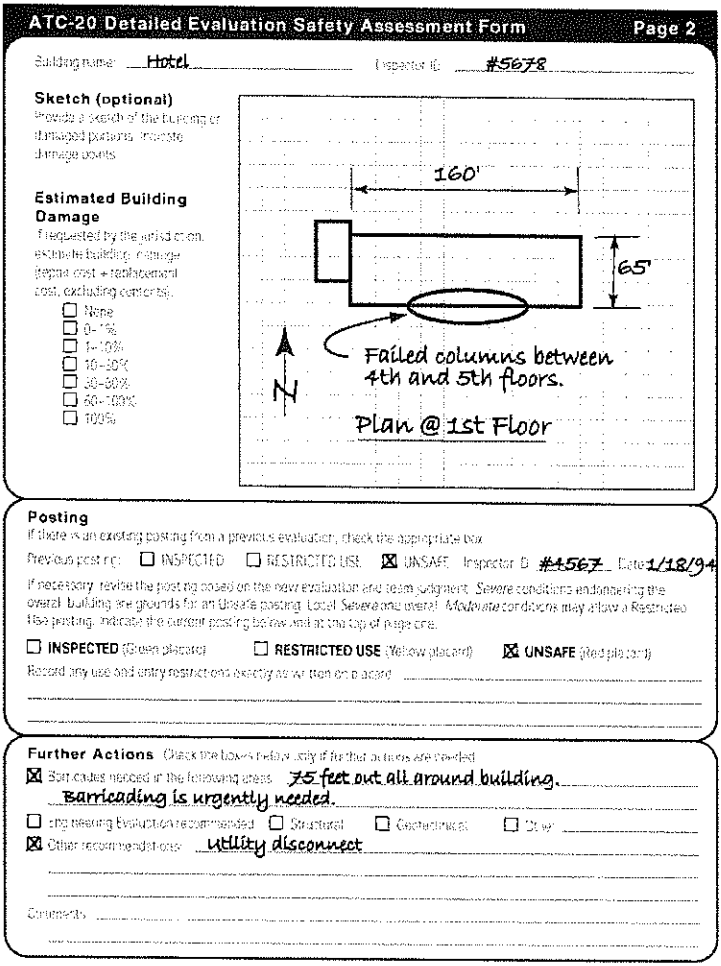


Figure E-18 Completed Detailed Evaluation assessment form for Example 4. (Continued)

UNSAFE

DO NOT ENTER OR OCCUPY
(THIS PLACARD IS NOT A DEMOLITION ORDER)

This structure has been inspected, found to be seriously damaged and is unsafe to occupy, as described below:
COLUMNS ON SOUTH SIDE OF BUILDING HAVE FAILED. BUILDING IS A COLLAPSE HAZARD.

Do not enter, except as specifically authorized in writing by jurisdiction. Entry may result in death or injury.

Facility Name and Address:
HOTEL
8301 ANY ST.

Date 1/19/94

Time 8:30 AM

This facility was inspected under emergency conditions for:
LOS ANGELES
(Jurisdiction)

Inspector ID / Agency
#5678
OES

Do Not Remove, Alter, or Cover this Placard until Authorized by Governing Authority

Figure E-19 UNSAFE placard for Example 4.

Appendix F. Web-Based Information

The web sites listed below provide useful information for individuals involved in postearthquake safety evaluations.

1. The Applied Technology Council (*www.atcouncil.org*) provides the following downloadable documents:
   - ATC-20 Posting Placards
   - ATC-20 Rapid and Detailed Evaluation Forms
   - ATC-20 Fixed Equipment Checklist
   - Guidance for Owners and Occupants of Damaged Buildings
   - ATC-TechBrief 2, *Earthquake Aftershocks - Entering Damaged Buildings*
2. U.S. Geological Survey (USGS) shake maps are available at *www.trinet.org/shake/index.html*
3. After an earthquake in California of magnitude 5 or larger, the USGS posts the probability of strong aftershocks at *http://quake.wr.usgs.gov/*
4. The California Integrated Seismic Network (CISN) provides reliable earthquake reporting and strong-motion information at *www.cisn.org/*

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8.10	Photograph by Joseph Nicoletti
8.6, 8.14, 11.5	Photographs by James Stratta
8.13	Original drawing from S. B. Barnes and C. W. Pinkham (in Murphy, 1973)

8.15, 8.16	Photographs from U.S. Army, Karl Steinbrugge collection
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5.6	Photograph by Eugene Schader, Karl Steinbrugge collection
12.1	Photograph from American Plywood Association, Karl Steinbrugge collection
12.9	Original drawing from Ayres, Sun and Brown, 1973
6.2	Drawing by Rutherford & Chekene
7.5, 8.12	Unknown
C.1	National Fire Protection Association
D.3	ATC Techbrief 2