

Post-disaster Building Safety Evaluation Guidance

Report on the Current State of Practice, including Recommendations Related to Structural and Nonstructural Safety and Habitability

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Post-disaster Building Safety Evaluation Guidance – Report on the Current State of Practice, including Recommendations Related to Structural and Nonstructural Safety and Habitability

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Cover image – Photos of disaster damage before, during, or after evaluation. Starting top left, going clockwise: (1) Residence posted with red UNSAFE placard following the 2016 South Napa earthquake; (2) residence damaged in hurricane (credit: Laurie Johnson); (3) damage following the 2018 Camp Fire in California (© Sacramento Bee / Hector Amezcua. Reprinted with permission.); and (4) residence damaged in tornado.

Foreword

The Federal Emergency Management Agency (FEMA) is grateful to the 115th United States Congress (2017-2018) for working with FEMA and other stakeholders as it considered and ultimately passed the *Disaster Recovery Reform Act* of 2018 (DRRA). This law contains important reforms to federal disaster programs, including ones that formally acknowledge the shared responsibility for disaster preparedness, mitigation, response, and recovery among all levels of government. The law also aims to reduce the complexity of FEMA and build the nation's capacity for the next catastrophic incident.

Many of the provisions found in the DRRA are focused on the existing buildings of our nation and how they should and can be assessed, retrofitted, repaired, or rebuilt to provide safety and resilience before, during, and after disasters. One such provision in the DRRA, Section 1241, *Post-disaster Building Safety Assessment*, directs FEMA to develop and publish this report on guidance, including best practices, for post-disaster evaluation of buildings by licensed architects and engineers to ensure that design professionals properly analyze the structural integrity and livability of buildings and structures after an array of natural hazard events, including: earthquakes; hurricanes; floods; tornadoes; tsunamis; landslides and other land instabilities; volcanoes; snow, hail, and ice storms; and fire; as well as damage from explosions.

This congressional mandate also requires FEMA to coordinate the development of this report with state, local, tribal, and territorial governments, as well as organizations representing building design professionals. Additionally, FEMA engaged the broader building safety community, including other federal agencies and individuals with expertise in building codes, indoor health, emergency management, and post-disaster public safety, to develop this report.

FEMA wishes to express its gratitude to the Applied Technology Council and the individuals listed on the title page as members of the Project Technical Committee and the Project Review Panel, and the participants of the stakeholder workshop convened as part of this guidance development effort. Without the expertise and hard work of these dedicated professionals, this project would not have been possible.

Federal Emergency Management Agency

Preface

Following the passage of the *Disaster Recovery Reform Act* (DRRA) in October 2018, FEMA commenced work with the Applied Technology Council (ATC) under Task Order Contract HSFE60-12-D-0242 to develop a guidance document for structural integrity and livability of buildings after disasters, as requested by the 115th United States Congress (2017-2018).

Development of the *Guide* included review and definition of post-disaster building safety evaluations and other types of assessments that often occur following an incident. Identification of best practices and, where necessary, interim recommendations, were done with the assistance of a project team with diverse background and expertise.

ATC is indebted to the leadership of Bret Lizundia, Project Technical Director, and to the members of the ATC-137-2 DRRA Project Team for their efforts in developing this *Guide*. The Project Technical Committee, consisting of Catherine Bobenhausen, Rosemarie Grant, Edwin Huston, Laurence Kornfield, Scott Nacheman, and Jim Olk, served as principal authors of the *Guide*. The Project Review Panel, made up of Jim Barnes, Steven Bibby, Karl Fippinger, Nathan Gould, Rachel Minnery, Eugene Pinzer, Ben Ross, and Jonathan Siu, provided technical review, advice, and consultation at key stages of the work. Input from stakeholders was received during an online workshop with participants representing a variety of stakeholder groups. The *Guide* also benefited from review and contributions by FEMA staff. The names and affiliations of all who contributed to this report are provided in the list of Project Participants.

ATC gratefully acknowledges the critical contributions of Drew Herseth (FEMA Project Manager) and Laurie Johnson (FEMA Subject Matter Expert) to development efforts, and input and guidance provided by Michael Mahoney (FEMA Project Officer). Carrie J. Perna (ATC) provided report production services.

Ayse Hortacsu	Jon A. Heintz
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Executive Summary

Section 1241(a) of the *Disaster Recovery Reform Act* (DRRA) of 2018 requires the Federal Emergency Management Agency (FEMA) to publish a report providing guidance on the best practices for post-disaster evaluation of buildings for both structural safety and habitability. This *Guide* summarizes and references best practice guideline documents, identifies recommended improvements and needs, and provides interim recommendations for issues without best practice guidance. The following incident types are covered: earthquakes; hurricanes; floods; tornadoes; tsunamis; landslides and other land instabilities; volcanoes; snow, hail, and ice storms; fire; and explosions. This *Guide* can be a reference for any post-incident evaluation process and is not limited by the scale or official declaration of a disaster.

Key conclusions of the *Guide* are as follows:

- Current post-disaster building safety evaluation guidelines for wind, flood, and earthquake incidents have a proven track record of success in past incidents. Only minor refinements are recommended.
- Best practice guidelines for other incident types are needed. The *Guide* provides interim recommendations and advice on what could be developed in the future.
- Past incidents have clearly demonstrated that in order for evaluation programs to work effectively, proper planning, management, and implementation are essential. Before the incident, this includes training and certifying building safety evaluators and evaluator supervisors to properly perform evaluations, training building officials and emergency managers in managing the evaluation process, developing appropriate emergency management plans, and making sure mutual aid resource agreements are in place and understood so they can be utilized when the incident exceeds local capacity. After the incident, this includes deployment safety, management, and prioritization of appropriate evaluators for the incident type and scale; effective collection and reporting of the data developed during the evaluation process such as placard posting status and rationale; and quality assurance oversight of field evaluators by experienced and technically qualified individuals. Effective post-incident management also includes policies on

reevaluation triggers for follow-on events, such as earthquake aftershocks; policies on how placards can be changed or removed; proper procedures for cordoning and barricading damaged buildings; and effective strategies for communicating with the public, media, and building owners.

- In many local jurisdictions across the United States, laws and policies are needed to properly implement post-disaster evaluations, including Good Samaritan Laws to protect the design professionals who volunteer as evaluators, and legislation to create the authority to evaluate and post buildings, deputize evaluators, restrict occupancy, and demolish buildings.
- The focus in the past for post-disaster evaluations has been on structural safety. However, even if the structure of a building has not been significantly damaged, the ability to reoccupy the building may be compromised by nonstructural damage, environmental hazards, or a lack of necessary services such as fire protection, plumbing, or elevators. The *Guide* provides a detailed discussion of pre-disaster habitability requirements and how they apply and are evaluated following an incident. The concept of allowing temporary, reduced standards for selected building services and systems until full repairs can be made is reviewed; issues and questions for communities to address are provided; and potential policy approaches are described.

Chapter 1 of the *Guide* introduces the DRRA Section 1241(a) charging language and the scope, purpose, target audience, and organization of the *Guide*. Chapter 2 provides context of post-disaster building safety evaluations and habitability considerations and how they are integrated into standardized emergency management procedures. Chapters 3 and 4 identify best practices for conducting structural and nonstructural safety and habitability evaluations. Chapters 5 and 6 provide guidance on evaluation program management and implementation issues before and after a disaster. Chapter 7 discusses emerging technologies and development needs. Chapter 8 synthesizes recommendations for three different audiences: (1) architects, engineers, and building officials directly involved in post-disaster building safety evaluation; (2) emergency managers and health officials who may be involved in the management of the post-disaster evaluation process, including environmental health issues; and (3) policy makers at the state, local, tribal, territorial, and federal government levels.

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Chapter 1

Introduction

1.1 Legislative Mandate

On October 5, 2018, President Donald J. Trump signed the *Disaster Recovery Reform Act* (DRRA) of 2018 into law as part of the Federal Aviation Administration Reauthorization Act of 2018. The goal of the DRRA is to improve the nation's capacity to respond to and recover from catastrophic events.

The law contains more than 50 provisions that require FEMA policy or regulation changes for full implementation. One of these is Section 1241, which is reproduced here.

> ***SECTION 1241. POST DISASTER BUILDING SAFETY ASSESSMENT.***
>
> *(a) BUILDING SAFETY ASSESSMENT TEAM.—*
>
> *(1) IN GENERAL.—The Administrator shall coordinate with State and local governments and organizations representing design professionals, such as architects and engineers, to develop guidance, including best practices, for post-disaster assessment of buildings by licensed architects and engineers to ensure the design professionals properly analyze the structural integrity and livability of buildings and structures.*
>
> *(2) PUBLICATION.—The Administrator shall publish the guidance required to be developed under paragraph (1) not later than 1 year after the date of enactment of this Act.*
>
> *(b) NATIONAL INCIDENT MANAGEMENT SYSTEM.—The Administrator shall revise or issue guidance as required to the National Incident Management System Resource Management component to ensure the functions of post-disaster building safety assessment, such as those functions performed by design professionals are accurately resource typed within the National Incident Management System.*
>
> *(c) EFFECTIVE DATE.—This section shall be effective on the date of enactment of this Act.*

Disaster vs. Incident

In this *Guide*, terminology is intended to be in general accordance with FEMA guidance as noted in Appendix A, *Glossary*. A disaster is defined as "an occurrence of a natural catastrophe, technological accident, or human-caused event that has resulted in severe property damage, deaths, and/or multiple injuries." The term incident is typically used to cover a broader context, as a disaster is when an incident rises to a more severe level. An incident is defined as "an occurrence, natural or human-caused, that necessitates a response to protect life or property. The word 'incident' includes emergencies and/or disasters of all kinds and sizes."

Evaluation vs. Assessment

In this *Guide*, the procedures used to determine building safety resulting in posted placards on damaged buildings are termed a "post-disaster building safety and habitability evaluation." The term "assessment" is used for other types of reviews that are conducted.

Building Safety and Habitability

In this *Guide*, the term "building safety" covers both structural and nonstructural safety.

While the term "habitability" is typically associated with residential structures, its use herein applies to both nonresidential as well as residential buildings that are deemed safe to occupy.

This *Post-Disaster Building Safety Evaluation Guidance* document (identified herein as the "*Guide*") was developed as required by Section 1241(a) by a technical team—under the direction of FEMA, with feedback from a project review panel, and informed by a stakeholder workshop. In developing this *Guide,* there was coordination with the FEMA National Integration Center addressing Section 1241(b); the guidance on resource typing required by Section 1241(b) will be issued separately.

1.2 Purpose and Scope of *Guide*

Post-disaster building safety evaluations have traditionally focused on structural safety—with the key question being whether the disaster has made the building sufficiently less safe than it was before the event to warrant limitations being placed on occupancy. However, even if structural integrity has not been compromised, the ability to occupy the building may be limited by other issues such as damage to nonstructural components, environmental hazards, or a lack of necessary utility and building systems, such as water, sewer, power, heat, fire alarm, and fire suppression systems. Guidance is needed to determine when these issues may also compromise occupancy. Finally, experience has shown that effective program planning and management of the post-disaster evaluation process is a critical need.

This *Guide* begins with a review and definition of post-disaster building safety evaluations and discusses other types of assessments that often occur following an incident. The *Guide* then summarizes issues related to structural integrity (termed building safety herein to more clearly identify the objective of evaluating both structural and nonstructural safety) and livability (termed habitability herein to more broadly cover not just residences but also other types of buildings, such as offices, schools, and stores).

This is followed by guidance on program planning prior to an incident and program management and implementation practices after an incident. Best practices and gaps are identified, and recommendations are made.

It is not the intent of this document to establish FEMA or other federal policy, nor to set standards or requirements. Rather, this *Guide* provides recommendations for consideration by others that have the authority to set standards. The *Guide* summarizes and references current best practice guideline documents. In some cases, potential improvements to these documents or issues to be investigated are identified. For some incident types or issues, guidance documents have not yet been developed or standardized, and needs are identified to fill these gaps. These recommendations will help serve as a road map for future efforts by the disaster response community.

1.3 Target Audience

There are three target audiences for this *Guide:*

- Primary: Architects, engineers, and building officials directly involved in post-disaster building safety evaluation.
- Secondary: Emergency managers and health officials who may be involved in management of the post-disaster evaluation process, including environmental health issues.
- Tertiary: Policy makers at state, local, tribal, and territorial (SLTT) and federal government levels.

The target audience has been expanded beyond the architects and engineers explicitly listed in DRRA Section 1241(a) charging language to include others who are directly involved in the post-disaster evaluation process and to policy makers since recommendations include legislative changes.

1.4 What is Covered

The focus of this *Guide* is on post-disaster evaluations of buildings for safety and habitability. Other types of damage or loss assessments, such as those for insurance or financial assistance, are mentioned briefly in Chapter 2 to provide context, but they are not the focus of the *Guide.*

Incident types covered by this report include earthquake; hurricane; tornado; flooding; tsunami; volcano; landslide and other land instabilities; snow, hail, and ice storms; fire; and explosion. Multi-hazard incidents are also covered, such as aftershocks and fires following earthquakes, mudslides and flash floods after wildfires, or fires caused by initial building damage but delayed due to hidden mechanical or electrical issues.

Incident size, severity, and associated building damage vary. Some incidents are localized; others can be regional. Although the primary focus of this document is on large scale incidents that have risen to the level of a disaster, guidance can apply to incidents of smaller scale and severity.

The frequency of different incident types varies. Table 1-1 summarizes FEMA disaster declaration data between May 2, 1953 and March 3, 2019, showing incident occurrences. The table shows that floods occur most frequently.

Table 1-1 FEMA Disaster Declarations Related to Building Damage from May 1953 to March 2019 (FEMA, 2019a)

Incident Type	Distinct Occurrences	Percentage of Total Declarations (*)
Flood	568	40.46%
Severe Storm(s)	378	26.92%
Tornado	143	10.19%
Hurricane	140	9.97%
Typhoon	41	2.92%
Fire	36	2.56%
Earthquake	20	1.42%
Freezing	14	1.00%
Coastal Storm	11	0.78%
Severe Ice Storm	10	0.71%
Snow	7	0.50%
Volcano	4	0.28%
Mud/Landslide	2	0.14%
Dam/Levee Break	1	0.07%
Human Cause	1	0.07%
Terrorist	1	0.07%

(*) Percentages above do not add up to 100% because disaster declaration data that do not result in building damage have not been included in the table.

In addition to damage to buildings, chemical spills and biological contamination resulting from building damage and flooding are also addressed; however, nuclear, chemical, and biological release incidents and terrorist activity not directly causing building damage are not within the scope of the *Guide*.

The *Guide* focuses on typical residential, commercial, and retail buildings. Specialized structures such as industrial facilities like refineries, airports, and ports, and other critical infrastructure facilities, such as nuclear power plants, are beyond the scope of this *Guide*, as they need special treatment and specialized resources. In addition, some buildings have specialized nonstructural elements and equipment that may require specialized evaluation beyond the scope of this *Guide*. These include laboratory centers used for disease control, some specialized manufacturing facilities, and some of the equipment in hospitals and other medical centers.

Figure 1-1 illustrates the topics covered by the *Guide* as they fit on the timeline of an incident. The focus of the *Guide* is on planning prior to the incident, conduct of evaluations immediately after the disaster, potential temporary habitability standards that can be implemented, and management and implementation strategies to aid in the evaluation process. The focus is on building safety and habitability evaluations during the response period; retrofitting buildings and other mitigation activities are outside the document scope, as are long-term repairs and rebuilding issues.

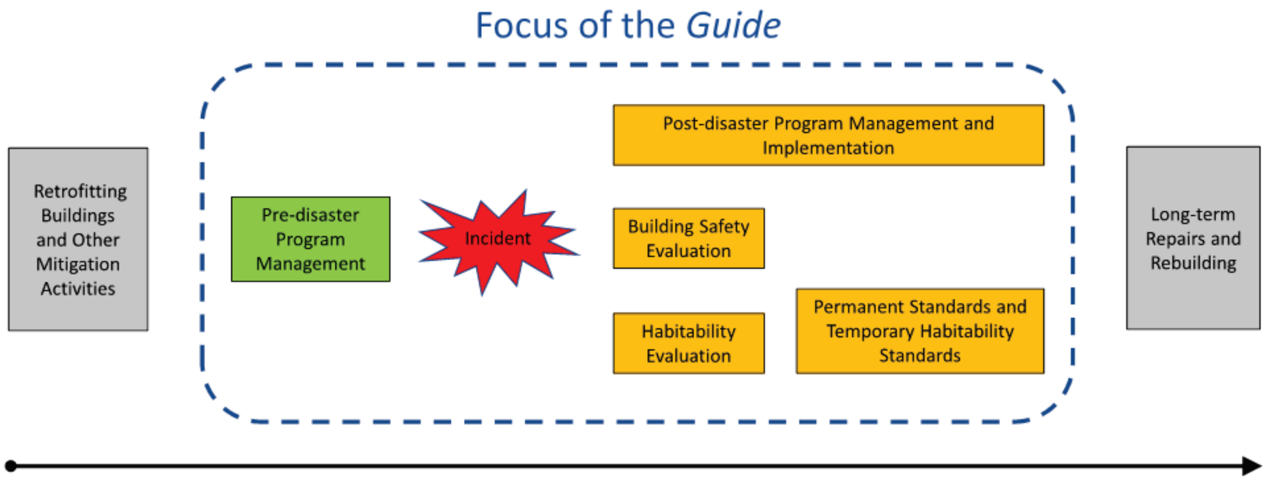

Figure 1-1 Graphic illustrating building safety evaluation topics covered by the *Guide*. The horizontal arrow indicates time in relation to the incident. Topics indicated in gray are outside of the scope of the *Guide*.

As shown in the timeline in Figure 1-1, this *Guide* covers a very specific need to identify which buildings are safe or unsafe to occupy after an incident. This evaluation helps reduce the overwhelming sheltering demands a community may face when impacted by a catastrophic disaster. The concept of shelters or sheltering, before, during, and after disasters are subjects that FEMA, and the emergency management community as a whole, have and will continue to be actively engaged in as the work to Build a Culture of Preparedness and Ready the Nation for Catastrophic Disasters[1] continues. The *National Response Framework* (NRF) (FEMA, 2019b) introduces the Community Lifeline construct and terminology. There are seven community lifelines that represent only the most basic services a community relies on and which, when stable, enable all other activity within a community; "food, water, shelter" is identified as one of the seven Community Lifelines as follows: "A community lifeline enables the continuous operation of critical government and business functions and is essential to human health and safety or economic security." The NRF also states "stabilizing community lifelines is the primary effort during response to lessen threats and hazards to public health and safety, the economy, and security."

[1] https://www.fema.gov/strategic-plan

The Community Lifelines construct is used to focus incident response actions on incident stabilization and anticipating, resourcing, and managing immediate threats to life and property and to ensure that basic lifeline services are provided to survivors, before restoration begins. Thus, the best practices and recommendations offered in this *Guide* have an important nexus with the planning and execution of sheltering stabilization and restoration efforts following an incident.

1.5 Organization of *Guide*

Where available, each section of the *Guide* includes a "Best Practice" heading that concisely summarizes available best practice guidance documents. If no documents are available, but an available document can be reasonably adapted for use, then this is listed as an "Interim Recommendation." In addition, where available, each chapter starts with a compilation of the best practice guidance in summary tables. Many sections also have a subsequent summary under the heading of "Additional Discussion and Needs" that describes improvements in existing documents that should be made or guidance that should be developed to fill missing gaps. Both near-term and longer-term recommendations are provided.

The remainder of the *Guide* is organized as follows.

- **Chapter 2, Context of Post-disaster Building Safety Evaluations,** discusses the context of post-disaster building safety evaluations and habitability considerations and how they are integrated into standardized emergency management procedures.
- **Chapter 3, Structural and Nonstructural Safety Evaluation,** summarizes current techniques for evaluating the safety of buildings when damaged by different incident types. The primary focus is on structural damage, but damage to key nonstructural elements is also addressed. Best practice guidelines and needs are identified.
- **Chapter 4, Habitability Evaluation and Other Considerations,** reviews FEMA policy on habitability requirements, evaluation techniques and issues for environmental hazards, permanent standards and potential temporary standards after an incident for mechanical/electrical/plumbing systems, fire alarm, carbon monoxide alarm, fire protection, habitable space, exiting, accessibility, and security.
- **Chapter 5, Pre-disaster Program Management,** summarizes best practice guidance for program management before a disaster, including resource typing, certification and training, pre-planning, mutual aid, liability, and recommended laws and policies.

- **Chapter 6, Post-disaster Program Management and Implementation,** covers implementing the post-disaster building safety section of emergency management plans, deployment safety, management, and priorities; data collection and reporting; quality assurance; triggers for re-evaluation; removing or changing a placard; cordoning and barricading; and communications with the public, media, and building owners.
- **Chapter 7, Emerging Technologies and Development Needs,** presents discussions on emerging technologies and future research and development needs.
- **Chapter 8, Conclusions and Recommendations,** presents key conclusions and synthesizes best practices and interim recommendations for three different audiences: (1) architects, engineers, and buildings officials directly involved in post-disaster safety evaluation; (2) emergency managers and health officials who may be involved in the management of the post-disaster evaluation process, including environmental health issues; and (3) policy makers at the SLTT and federal government levels.

A glossary and list of acronyms, a list of codes and standards referenced, a reference section, and a list of project participants are provided at the end of this report. Many sections also include a list of "Resources" with references, and, where available, links to useful websites and programs are provided in footnotes. Links to organizations involved in post-disaster building evaluations and assessments are also included. All websites were available when last accessed in August 2019.

Chapter 2

Context of Post-disaster Building Safety Evaluations

2.1 Overview

The basic components of building safety evaluations are universal to most incident types. After an incident, qualified professionals conduct reviews of damaged, or potentially damaged, buildings to evaluate safety and habitability for continued use and to determine the need for restricted or prohibited entry. Evaluation types include very broad windshield evaluations, rapid evaluations, more detailed evaluations, and engineering evaluations. One evaluation can lead to requirements for the next. The purpose of building safety evaluations is to keep occupants safe following the incident and promote short-term and long-term recovery.

Post-disaster building safety evaluations are a key activity following an incident, but they are only one of several activities. The following provides a short summary of key activities following a large-scale incident in the order they usually occur. Circumstances vary by the individual incident:

1. Incident occurs.
2. Initial information is gathered on the severity and location of the damage.
3. First responders, including police and fire personnel, perform initial assessments of buildings, cordon off areas with downed power lines and other hazardous conditions, and get injured people to appropriate medical care.
4. Building officials and/or other local authorities conduct a windshield or flyover survey of damaged areas to further assess the severity and distribution of damage.
5. Urban search and rescue personnel locate and extricate people trapped in damaged buildings.
6. Remains of deceased are recovered.
7. Utility personnel investigate and address downed power lines, gas leaks, and other equipment damage or hazardous conditions.
8. Post-disaster building safety evaluations are conducted by trained building department personnel and when necessary, by trained and

deputized post-disaster building safety evaluators. For larger incidents, mutual aid may be requested to obtain additional evaluators from outside the affected area.

9. The building safety evaluation process includes limited reviews of nonstructural hazards that can affect the ability to reoccupy the building. Building safety evaluators also perform limited, initial environmental hazard scans and alert appropriate supervisors, emergency responders, or specialists if issues such as potentially toxic chemical spills, downed power lines, or natural gas leaks are observed.
10. Environmental hazards are reviewed by trained personnel from agencies, such as the local health department.
11. The building safety evaluation process could result in a building-specific or area-wide cordon or barricade.

This process has generally worked well in past incidents, but planning, training, and clearly defined roles are important.

Section 2.2 presents an overview of well-established post-disaster building safety evaluation procedures. Section 2.3 presents information on FEMA assistance programs that may reimburse some expenses associated with post-disaster building safety evaluations. There are a variety of other government-funded and non-government-funded assessments that can occur following an incident. Some examples are given in Section 2.4. Section 2.5 provides building code administration and enforcement requirements and authorities given to building code officials for safety evaluations. Section 2.6 describes the National Incident Management System (NIMS) and how building safety evaluations benefit from the use of NIMS.

2.2 Well-established Post-disaster Building Safety Evaluation Guidance

There are well-established post-disaster building safety evaluation guidelines for earthquakes, windstorms, and floods. An overview is provided here.

The Applied Technology Council (ATC) first published the ATC-20 report, *Procedures for Postearthquake Safety Evaluation of Buildings*, (ATC, 1989) to document procedures and guidelines for the safety evaluation of damaged buildings following earthquakes. Shortly after the completion of the ATC-20 report, the methodology was used following the magnitude-6.9 Loma Prieta earthquake that struck the San Francisco Bay Area in California and caused casualties and significant damage to buildings and infrastructure. ATC has continued to refine and augment the original ATC-20 report, and there are now a family of related documents, including the ATC-20-1 *Field Manual: Procedures for Postearthquake Safety Evaluation of Buildings, Second Edition* (ATC, 2005). ATC-20-1 procedures are considered the de facto standard in the United States and in many parts of the world for post-earthquake building safety evaluation.

In 2004, the ATC-45 report, *Field Manual: Safety Evaluation of Buildings after Windstorms and Floods*, (ATC, 2004) was published to provide procedures for evaluating building safety after hurricanes, tornados, other windstorms, floods, and explosions.

ATC-20-1 and ATC-45 procedures are written specifically for use by qualified professionals who are required to make on-the-spot evaluations and decisions regarding continued use and occupancy of damaged buildings. They both provide procedures and forms for Rapid Evaluations and Detailed Evaluations that result in the posting of buildings as INSPECTED (green placard), RESTRICTED USE (yellow placard) or UNSAFE (red placard). See Figure 2-1 for examples of the placards. Also included in ATC-20-1 and ATC-45 are special procedures for evaluation of essential buildings (e.g., hospitals), evaluation procedures for nonstructural elements (such as ceilings, partitions, and cladding), geotechnical hazards, and limited guidance on dealing with occupants and owners of damaged property.

Rapid Evaluations typically take an average of 30 minutes per building and provide an initial general evaluation of damage and safety; the suggested personnel include structural engineers, professional engineers with a specialization in structures, architects, building officials, building inspectors, and experienced general contractors. Entry into damaged buildings should be done according to guidance in ATC-20-1 and ATC-45.

As noted in ATC-20-1:

> *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 the building.*
>
> *When done as part of Rapid Evaluations, interior inspections are typically of short duration and limited scope. Unless authorized by the local jurisdiction, building should not be entered without the permission of the owner or occupant.* ***Do not enter obviously unsafe buildings.***

Evaluation Types

Windshield or Reconnaissance Survey: Conducted by building officials or emergency response managers prior to sending evaluation teams to the field, done either on the ground or by air, to determine the nature and extent of building damage in an area and to prioritize regions that should be evaluated. Buildings are normally not posted with placards during this phase.

Rapid Evaluation: Average of 30 minutes per building to provide an initial general evaluation of damage and safety and quickly identify and post UNSAFE and apparently safe structures, and to identify buildings requiring Detailed Evaluation or necessary restrictions on building use.

Detailed Evaluation: Average of one to four hours per building to provide a careful visual examination of the building and its structural system. Used to evaluate questionable buildings, to identify necessary restrictions on building use or to identify the need for an Engineering Evaluation.

Engineering Evaluation: Detailed engineering investigation of damaged buildings, involving use of construction drawings, damage data, and new structural calculations. Used to evaluate questionable buildings, to determine the extent of damage, and to determine how to stabilize and repair the building.

Figure 2-1 INSPECTED, RESTRICTED USE, and UNSAFE placards from ATC-20-1.

Detailed Evaluations take one to four hours per building; they are a more thorough visual examination of the building and its structural system; they occur after an initial Rapid Evaluation (or sometimes in lieu of a Rapid Evaluation); and structural engineers, professional engineers with a specialization in structures, and architects are the recommended personnel. In some cases, geotechnical engineers or hydrologic engineers may be needed, depending on the conditions at the site. See Section 2.6 and Section 5.3 for more information on personnel and building safety evaluation team composition.

Detailed Evaluations are sometimes performed by consultants hired by the owner. The selection of the evaluation team resource types and skills will also depend on the complexity of the building design. Evaluation of very complex buildings can require longer than four hours, and it can be complicated by evaluations of highly specialized equipment (e.g., magnetic resonance imaging (MRI) devices). A third level of evaluation, termed an Engineering Evaluation, is defined but not discussed in detail in ATC-20-1 or ATC-45. It is conducted by structural engineering, geotechnical, or hydrologic consultants hired by the owner.

The ATC-20-1 and ATC-45 methodologies are unique in their ability to provide a rapid evaluation of the extent and significance of reductions in lateral force-resisting and gravity load-carrying capacity. Other building evaluation methods exist, but they are generally more costly, more time-consuming, can require more experience, and in some cases are focused on specific structural systems.

ATC has initiated an update of ATC-20-1 to incorporate lessons that have been learned from post-earthquake safety evaluations around the world. Details are discussed in Section 3.2.

A key point to recognize is that ATC-20-1 and ATC-45 focus on evaluations of buildings to address the key question of whether the earthquake, windstorm, or flood has reduced a building's strength, stiffness, or stability, making it sufficiently less safe than it was before the incident to warrant limitations being placed on occupancy. The documents provide only limited discussion of environmental hazards and building services that may significantly impact the usability of the building.

ATC-20-1 and ATC-45 establish detailed, clear procedures for Rapid Evaluations and Detailed Evaluations following earthquake, windstorm, and flood incidents. The same approach of using Rapid and Detailed Evaluations by trained, qualified evaluators is recommended for other incident types. Chapter 3 provides interim recommendations for other incident types.

Although the traditional focus of ATC-20-1 and ATC-45 evaluations has been on structural safety, evaluation procedures include review of nonstructural hazards and scans for environmental hazards. Thus, even when the structure has no significant damage, a building may be posted as RESTRICTED USE or UNSAFE when habitability is compromised due to other issues such as mold contamination, blocked exits, or toxic chemical spills. Chapter 4 discusses habitability considerations are part of the post-disaster evaluation process.

2.3 FEMA Grant Assistance for Post-disaster Building Safety Evaluations

The *Robert T. Stafford Disaster Relief and Emergency Assistance Act*, as Amended (*Stafford Act*), Title 42 of the United States Code (U.S.C.) § 5121 et seq., authorizes the President to provide federal assistance when the magnitude of an incident or threatened incident exceeds the affected state, local, tribal, and territorial (SLTT) government capabilities to respond or recover. When authorized, FEMA may provide assistance to SLTT governments, and certain types of private nonprofit organizations through the

Public Assistance (PA) Grant Program. The mission of the FEMA PA Program is to provide assistance so that communities can quickly respond to and recover from major disasters or emergencies declared by the President. Through the PA Program, FEMA is authorized to provide funding for Emergency Work, including Emergency Protective Measures. Emergency Work is that which must be done immediately to save lives, protect public health and safety, protect improved property, or eliminate or lessen an immediate threat of additional damage.

Emergency Protective Measures conducted before, during, and after an incident are eligible for FEMA PA Program assistance if the measures:

- Eliminate or lessen immediate threats to lives, public health, or safety; or
- Eliminate or lessen immediate threats of significant additional damage to improved public or private property in a cost-effective manner.

One action listed in the *Public Assistance Program and Policy Guide* (FEMA, 2018) as an Emergency Protective Measure is Safety Inspections, described as follows:

> ***Safety Inspections***
>
> *Post-incident safety inspections for public and private facilities are eligible, as well as posting appropriate placards (e.g., "red-tagging" a building that is unsafe).*
>
> *The specific purpose of the inspection must be to determine whether the facility is safe for entry, occupancy, and lawful use. The Applicant must clearly substantiate that the purpose of the inspection was for safety and not to assess damage. Building inspections are not eligible if the purpose of the inspection is to:*
>
> - *Determine whether the building is Substantially Damaged for the purpose of compliance with the community's floodplain management ordinance;*
> - *Determine whether the building needs to be elevated or relocated, in accordance with the community's floodplain management ordinance; or*
> - *Ensure that repairs are completed in accordance with the community's building code or standard.*

Based on this definition of Safety Inspections in the FEMA PA Program, both Rapid Evaluations and Detailed Evaluations, as defined in Section 2.2, could be considered as eligible expenses. However, Engineering

Evaluations, also defined in Section 2.2, will most likely only be considered as eligible expenses if the building is owned by an eligible applicant of the FEMA PA Program.

Another form of assistance the FEMA PA Program may provide is reimbursement of eligible costs based on a mutual aid agreement. When a jurisdiction does not have sufficient resources to respond to an incident, it may request resources from another jurisdiction through a mutual aid agreement, as detailed in *Public Assistance Program and Policy Guide* (FEMA, 2018). The Emergency Management Assistance Compact (EMAC) is a national interstate mutual aid agreement that enables states and territories to share resources in response to an incident and is discussed in more detail in Section 5.5.

It is important to note that the assistance provided through the FEMA PA Program is subject to a cost share. Although the federal share is usually 75 percent of the eligible costs, if actual Federal obligations, excluding administrative costs, meet or exceed a qualifying threshold, FEMA may recommend an increase up to 90 percent. The federal cost share for Emergency Work may be increased in limited circumstances if warranted. Furthermore, FEMA is legally prohibited from duplicating benefits.

Additionally, Sections 402 and 406 of the *Stafford Act*, as amended by Section 1206 of the *Disaster Recovery Reform Act*, authorize FEMA to provide post-disaster assistance to state and local governments for building code and floodplain management ordinance administration and enforcement. As of the completion date of this *Guide*, the implementation policy for these amendments to the *Stafford Act* is still being developed.

2.4 Other Types of Building Assessments

After an incident, it is likely that there will be several types of assessment teams surveying damaged buildings. The teams will often have different missions and objectives, though they will also have some commonalities that may help inform building safety evaluations and recovery efforts for the community. A brief overview of these other assessments is provided here for context.

2.4.1 Preliminary Damage Assessment

Once a disaster has occurred or is imminent, the state, territorial, or tribal government will evaluate their own response and recovery capabilities. If they determine that the extent of the disaster is more than what they are capable of responding to on their own, the state, territorial, or tribal government can contact their FEMA Regional Office and request a federal disaster declaration. A joint federal, state, territorial, or tribal Preliminary Damage Assessment[1] (PDA) will then be conducted, unless it is waived for incidents of unusual severity and magnitude. Local government representatives should be included in the PDA process, if possible.

The PDA team will conduct a thorough assessment of the impacted area to determine the extent of the disaster, its impact on individuals[2] and public facilities[3], and the types of federal assistance that may be needed. If it is determined that the damage is beyond their response and recovery capability, the state, territorial, or tribal leadership will send a request letter to the President, informed by the PDA, directed through the Regional Administrator of the appropriate FEMA region, and showing that the disaster is of such severity and magnitude that effective response is beyond the capabilities of the state, territorial, tribal governments, and the affected local governments and that supplemental federal assistance is necessary. The President then makes the decision of whether or not to declare a major disaster or emergency.

Damage Assessment Operations Manual (FEMA, 2016) is used to help expedite decision-making and the delivery of assistance by defining national standards for assessing damage and clearly outlining the information considered when evaluating requests for a Major Disaster Declaration. The *Manual* states that the joint PDA field teams are intended to validate—not find—damage and impact information. The teams validate damage to support the rapid development of information needed by state, territorial, and tribal leadership to request a Major Disaster Declaration from the President. A Presidential Disaster Declaration is necessary in order to trigger federal Public Assistance and Individual Assistance Program support for a community.

2.4.2 FEMA Home Inspections

As part of the FEMA Individual Assistance (IA) Program, a home inspection may be required in order to verify disaster-caused damage and loss as part of the process of determining the assistance options available for survivors. More information on how the FEMA IA Program addresses post-disaster habitability of a primary residence is provided in Section 4.2.

[1] 44 CFR § 206.33 - Preliminary damage assessment.
[2] 44 CFR § 206.48(b) - Factors for the Individual Assistance Program.
[3] 44 CFR § 206.48(a) - Public Assistance Program.

Resources

- *Fact Sheet: What you Need to Know: Housing Inspections*: https://www.fema.gov/news-release/2018/11/21/4407/fact-sheet-what-you-need-know-housing-inspections
- *Home Inspection after FEMA Registration*: https://www.fema.gov/news-release/2018/09/28/home-inspection-after-fema-registration
- *Individual Disaster Assistance*: https://www.fema.gov/individual-disaster-assistance

2.4.3 FEMA Public Assistance Site Visits and Inspections

As part of the FEMA PA Program discussed in Section 2.3, representatives from FEMA and the disaster-impacted SLTT governments may inspect sites to validate, quantify, and document the cause, location, and details of the disaster-caused damage that may be eligible for disaster assistance funding from FEMA and evaluate and collect any additional information on the damaged or destroyed infrastructure. Often, this will entail a physical inspection by a team including a FEMA site inspector and a representative from the SLTT governments, or private nonprofit organization.

The local government is responsible for explaining how they plan to repair the damage, including if changes to the pre-disaster design and/or function of a structure are due to codes and standards.

Resources

- FEMA Public Assistance Program Overview: https://www.fema.gov/public-assistance-local-state-tribal-and-non-profit

2.4.4 Substantial Damage Determinations

A term defined by the National Flood Insurance Program (NFIP) and building codes, Substantial Damage, applies to buildings located in Special Flood Hazard Areas (SFHAs) or floodplains. A Substantial Damage determination is triggered when the total cost of repairs is 50 percent or more of the building's market value before the damage occurred, regardless of the cause of damage. Note, Substantial Damage is more than just the damage to the structural elements of a building; it includes damage to nonstructural features, finishes, and mechanical systems.

The determination of Substantial Damage is made at the local government level, generally by a building department official or floodplain manager. Community or state-led floodplain management Disaster Response Teams, or local building officials may be assembled to inspect properties to determine if homes and businesses have been substantially damaged. FEMA's *Substantial Damage Estimator*[4] tool enables local officials to calculate an estimate of whether a building has been substantially damaged.

A Substantial Damage determination is important in that it triggers specific requirements for the use (continued occupancy) of the building. If a structure in the SFHA has been substantially damaged, the owner generally has several options to bring the structure into compliance:

- Elevate[5] the building to or above a height determined by local officials and bring all other aspect into compliance.
- Floodproof[6] the structure (nonresidential only).
- Demolish or relocate[7] the structure outside the floodplain.

It is important to note that although most often related to flooding, Substantial Damage determinations are required regardless of the cause of damage when structures are in a SFHA. This means that wind, wildfire, or seismically impacted structures, that also happen to be located in a SFHA, may also become subject to the compliance triggers above.

While Substantial Damage applies to buildings in SFHAs, there is a related concept termed Substantial Structural Damage that applies to all incident types and defines the threshold of damage that triggers upgrading of the structure to the current building code rather than just to the pre-incident state as part of the repairs.

Substantial Structural Damage is different from Substantial Damage, despite the similar names. The *International Existing Building Code* (IEBC) defines Substantial Structural Damage in terms of the loss of certain structural capacity. Generally, in Substantial Structural Damage, one or both of the following have occurred: the lateral force-resisting system has suffered damage and/or the capacity of a vertical component been reduced (IEBC presents specifics). It is important to note that while a Substantial Damage determination is based on the total cost of repairs, nonstructural damage does not count toward a Substantial Structural Damage determination.

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[4] FEMA P-784, *Substantial Damage Estimator (SDE) Tool* (2017): https://www.fema.gov/media-library/assets/documents/18692

[5] FEMA P-312, Chapter 5 - Elevating Your Home (2014): https://www.fema.gov/media-library/assets/documents/480

[6] FEMA P-936, Floodproofing Non-Residential Buildings (2013): https://www.fema.gov/media-library/assets/documents/34270

[7] FEMA P-312, Chapter 6 - Relocation and Demolition (2014): https://www.fema.gov/media-library/assets/documents/480

It is possible for a building to sustain both Substantial Damage and Substantial Structural Damage in the same incident, in which case both sets of requirements will apply. While Substantial Damage determinations are generally made by a building official or a floodplain manager, Substantial Structural Damage determinations will be made by a building official. The Substantial Damage and Substantial Structural Damage inspections may be made currently or separately and may occur as, or just after, post-disaster safety evaluations are being completed.

Resources

- *Fact Sheet: What Does "Substantial Damage" Mean?*: https://www.fema.gov/news-release/2018/11/20/fact-sheet-what-does-substantial-damage-mean
- *Understanding Substantial Damage in the International Building Code, International Existing Building Code, or International Residential Code*: https://www.fema.gov/media-library/assets/documents/130382
- *Understanding Substantial Structural Damage in the International Existing Building Code*: https://www.fema.gov/media-library/assets/documents/130384

2.4.5 FEMA Building Performance and Mitigation Assessment Teams

FEMA may deploy teams of subject matter experts in Mitigation Assessment Teams (MAT) or Building Performance Assessment Teams (BPAT) to investigate and assess the performance of buildings and related infrastructure in response to the effects of natural and human-caused hazard incidents to identify trends in building performance successes and failures. These teams develop recommendations for improvements in building design and construction and develop recommendations concerning consensus codes and standards development and enforcement. In addition, their findings assist in the development of mitigation recommendations that will lead to greater resistance to hazards. Their observations and recommendations are presented in reports published by FEMA.

Resources

- *What is the Mitigation Assessment Team Program?*: https://www.fema.gov/what-mitigation-assessment-team-program

2.4.6 Utility Inspections

Most incidents will have some type of impact on the operational status of on-site utilities. Damage may occur to the overall infrastructure system or may be site specific.

In the days immediately following a disaster, teams from utility companies as well as private contractors will be conducting assessments and repairs (Figure 2-2). If the incident is anticipated, such as a hurricane, utility repair crews may be pre-positioned so that repairs to the systems can be initiated immediately and may be in progress even before building safety evaluation personnel have been deployed.

Figure 2-2 Power restoration after Hurricane Harvey.

One of the initial actions of first responders after a disaster is to ensure that gas valves are turned off to damaged structures where gas leaks have been detected or are suspected. This often occurs in tandem with the search and rescue operation. In earthquake prone areas, automatic shut-off valves are available, and occupants may be trained to locate and shut off the gas immediately after an incident when they detect the odor of natural gas.

Many utilities will not reestablish service to a building until the local municipal inspector has inspected, approved, and posted the installation (procedures vary by locale) (Figure 2-3). It is important that specialized inspectors, such as electrical and heating, ventilation, and air-conditioning (HVAC) inspectors, be available for these tasks, and when appropriate supplemented by appropriately trained personnel. This underscores the importance of mutual aid agreements and the ability of a jurisdiction to obtain resources specifically qualified for the task, such as International Code Council (ICC) Certified Inspectors. These municipal specialty inspectors may also be in the field while building safety evaluations are being conducted.

Figure 2-3 Example of an inspected and approved installation ready to be connected to the utility's power grid. Source: Trinity Technologies http://www.trinitytechelectric.com/images/cell/Electrical/Final%20inspection%20sticker%20(3).jpg.

2.4.7 Insurance Claim Assessment

Insurance companies will deploy claims adjusters to assess insured properties soon after an incident. Most states have mandatory contact requirements that insurers are obligated to follow once a policyholder has contacted the company. There will be several kinds of adjusters in the field: insurance company employees and their contracted adjusters, and adjusters working on behalf of claimants. The responsibility of the adjusters is to determine the amount of damage that is covered under the insured's policy at the time of the incident. In some cases, insurance companies contract with engineers to assist them in this task and determine the extent of repairs needed. Some companies will also adjust flood damage losses on behalf of the NFIP, as well as earthquake damage losses on behalf of the California Earthquake Authority. Public insurance companies, such as Florida's Citizens Property Insurance Corporation, use internal and contract adjusters, just as a private insurance company might. The Texas Windstorm Insurance Association's claims are assigned to qualified independent adjusting firms.

If the policy provides Additional Living Expenses (ALE), the insured will be compensated for off-premises housing costs. Depending on the duration of time necessary to repair or replace the structure, this temporary housing could be a hotel room, an apartment, or a rental house. The insurance company will make the determination on providing ALE independent of posted placards. It should be noted that the NFIP does not offer ALE as a part of its coverage.

2.4.8 Research Organization Assessments

Groups of experts often conduct site visits in order to better understand building performance and the effects of incidents on society. Examples of such groups include: American Society of Civil Engineers Structural Engineering Institute[8], Earthquake Engineering Research Institute[9], Roofing Industry Committee on Weather Issues[10], Insurance Institute for Business and Home Safety[11], and government agencies such as the National Institute of Standards and Technology[12], the U.S. Geological Survey[13], and the National Oceanic and Atmospheric Administration[14].

In addition, researchers from universities may also deploy to collect information on damaged structures and infrastructure, and also observe the geological, sociological, economic, environmental, and health-related impacts of disasters. Examples include the Disaster Research Center of the University of Delaware[15] and the Natural Hazards Center at the University of Colorado Boulder[16]. The National Science Foundation (NSF)[17] regularly funds post-disaster research. As an example, in 2017 the NSF awarded $5.3 million in 59 grants to study effects of hurricanes (NSF, 2017).

NSF also funds the CONVERGE Facility[18], headquartered at the University of Colorado Boulder Natural Hazards Center, to coordinate hazards and disaster researchers from the following organizations: Social Science Extreme Events Reconnaissance (SSEER); Interdisciplinary Science and Engineering Extreme Events Reconnaissance (ISEEER); Geotechnical Extreme Events Reconnaissance (GEER)[19]; Structural Engineering Extreme Events Reconnaissance (StEER)[20]; the Natural Hazards Engineering Research Infrastructure (NHERI) RAPID Facility; and the NHERI DesignSafe-Cyberinfrastructure[21].

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8 https://www.asce.org/structural-engineering/structural-engineering-institute/
9 https://www.eeri.org/
10 https://www.ricowi.com/
11 https://disastersafety.org/
12 https://www.nist.gov/
13 https://www.usgs.gov/
14 https://www.noaa.gov/
15 https://www.drc.udel.edu/
16 https://hazards.colorado.edu/
17 https://www.nsf.gov/
18 https://converge.colorado.edu/
19 http://www.geerassociation.org/
20 https://www.steer.network
21 https://www.designsafe-ci.org/

2.5 Building Code Administration and Enforcement Requirements for Building Safety Evaluations

Most U.S. jurisdictions adopt or use an amended version of the model building codes maintained by the ICC, which include the IEBC, *International Building Code* (IBC), *International Residential Code* (IRC), and *International Property Maintenance Code* (IPMC). Both the IBC and IRC contain *Scope and Application* sections (A101.4.7 and R102.7) that incorporate by reference the IEBC and IPMC, respectively, for existing buildings.

Each of the model codes contain provisions that cover the administration and enforcement of the codes including the following sections that address the authorities granted to code officials related to building safety evaluations and the resulting action that may be needed.

The building official has the authority to prevent access to a structure or facility that they deem as damaged and unsafe:

> IBC Section A116.1 Conditions: *Structures or existing equipment that are or hereafter become unsafe, insanitary or deficient because of inadequate means of egress facilities, inadequate light and ventilation, or that constitute a fire hazard, or are otherwise dangerous to human life or the public welfare, or that involve illegal or improper occupancy or inadequate maintenance, shall be deemed an unsafe condition. Unsafe structures shall be taken down and removed or made safe, as the building official deems necessary and as provided for in this section. A vacant structure that is not secured against entry shall be deemed unsafe.* (ICC, 2018a)

Similar and supporting provisions for posting buildings can also be found in the following:

- IEBC Section 115 *Unsafe Buildings and Equipment*
- IEBC Section 116 *Emergency Measures*
- IPMC Section 108 *Unsafe Structures and Equipment*
- IPMC Section 109 *Emergency Measures*

The code official has the authority to deputize or delegate certain powers of their authority:

> IEBC Section A103.3 Deputies: *In accordance with the prescribed procedures of this jurisdiction and with the concurrence of the appointing authority, the code official shall have the authority to appoint a deputy code official, the related technical officers, inspectors, plan*

> *examiners, and other employees. Such employees shall have powers as delegated by the code official.* (ICC, 2018b)

Similar provisions can also be found in Sections A103.3 of the IBC and IPMC, as well as Section R103.3 in the IRC. Additional discussion regarding deputization is in Section 5.7 of this *Guide*.

The building official or a designee also has the authority to inspect for unsafe conditions:

> IRC Section R104.6 Right of Entry: *Where it is necessary to make an inspection to enforce the provisions of this code, or where the building official has reasonable cause to believe that there exists in a structure or upon a premises a condition that is contrary to or in violation of this code that makes the structure or premises unsafe, dangerous or hazardous, the building official or designee is authorized to enter the structure or premises at reasonable times to inspect or to perform the duties imposed by this code, provided that if such structure or premises be occupied that credentials be presented to the occupant and entry requested. If such structure or premises is unoccupied, the building official shall first make a reasonable effort to locate the owner, the owner's authorized agent, or other person having charge or control of the structure or premises and request entry. If entry is refused, the building official shall have recourse to the remedies provided by law to secure entry.* (ICC, 2018d)

Similar provisions can also be found in Sections A104.6 of the IBC and IEBC, as well as Section A104.3 of the IPMC.

Code officials also have the authority to close sidewalks and streets adjacent to unsafe buildings:

> IPMC Section 109.3 Closing Streets: *When necessary for public safety, the code official shall temporarily close structures and close, or order the authority having jurisdiction to close, sidewalks, streets, public ways and places adjacent to unsafe structures, and prohibit the same from being utilized.* (ICC, 2018c)

A similar provision can also be found in Section A116.3 of the IEBC.

See Section 6.10 for more information on cordoning and barricading. Additional discussion of code requirements related to building repairs is in Section 6.9.

2.6 Resources for Building Safety Evaluations under the National Incident Management System

The National Incident Management System[22] (NIMS), developed by the Department of Homeland Security (DHS), provides a scalable, common, nationwide approach to enable the whole community to work together to manage all threats and hazards and to provide a uniform set of processes and procedures that all emergency responders at all levels of government will use to conduct response operations. NIMS was released in 2004 and updated in 2008 and 2017. In 2003, *Homeland Security Presidential Directive –5* (DHS, 2003) tied the receipt of federal preparedness funds, grants, contracts and other activities to the adoption of NIMS at the state and local level.

NIMS guides all levels of government, nongovernmental organizations, and the private sector to work together to prevent, protect against, mitigate, respond to, and recover from incidents. NIMS provides all participants with common language, systems, and processes to successfully deliver the capabilities described in the National Preparedness System[23].

NIMS provides guidance on the implementation of uniform resources that meet defined minimum criteria. This concept is known as resource typing and establishes a common language for discussing resources by defining minimum capabilities for personnel, teams, facilities, equipment, and supplies. Resource typing enables communities to plan for, request, and have confidence that the resources they receive have the capabilities they requested.

Universally accepted plain language, as used in NIMS, with associated capabilities is integral for sharing resources among jurisdictions via mutual aid. Without this common operational language, requests for support can often be misinterpreted and incorrect resources may be deployed.

FEMA leads the development and maintenance of NIMS resource typing definitions that are national in scope. The FEMA National Integration Center (NIC) is responsible for establishing and maintaining the *Resource Typing Library Tool*[24] of resource typing definitions and is currently leading the development of resource types to define the minimum capabilities of building safety evaluation teams and personnel. See Section 5.3 for further details.

[22] https://www.fema.gov/national-incident-management-system
[23] https://www.fema.gov/national-preparedness-system
[24] https://rtlt.preptoolkit.org

Chapter 3

Structural and Nonstructural Safety Evaluation

3.1 Overview

This chapter presents best practices and recommendations for evaluating safety of buildings following an incident. Safety of occupants in a building following an incident can be at risk due to reduced capacity of structural components or damage to nonstructural components. Building safety evaluation of nonstructural components primarily focuses on their risk to life safety such as a damaged canopy over an exit. When nonstructural component damage impacts the functionality of the mechanical, electrical, or plumbing component, such as the loss of power or loss of a functioning fire sprinkler, it can compromise the habitability of the building. Chapter 3 covers structural and nonstructural safety evaluations; Chapter 4 covers habitability evaluations and other related considerations. In some cases, the two subjects are interrelated, such as when structural or nonstructural component damage blocks a fire exit. Building safety evaluations typically occur first, and include a limited, initial environmental hazard scan to alert others as appropriate. Later, if needed, more detailed evaluations are conducted by environmental specialists and building systems specialists, as discussed in Chapter 4. Figure 3-1 provides a summary of the scope of review by the Post-disaster Building Safety Evaluator.

Structural vs. Nonstructural Components

Per ASCE/SEI 41-17 (ASCE, 2017b), a structural component is "a component of a building that provides gravity- or lateral-load resistance as part of a continuous load path to the foundation, including beams, columns, slabs, braces, walls, wall piers, coupling beams, and connections."

A nonstructural component is "an architectural, mechanical, or electrical component of a building that is permanently installed in, or an integral part of, a building."

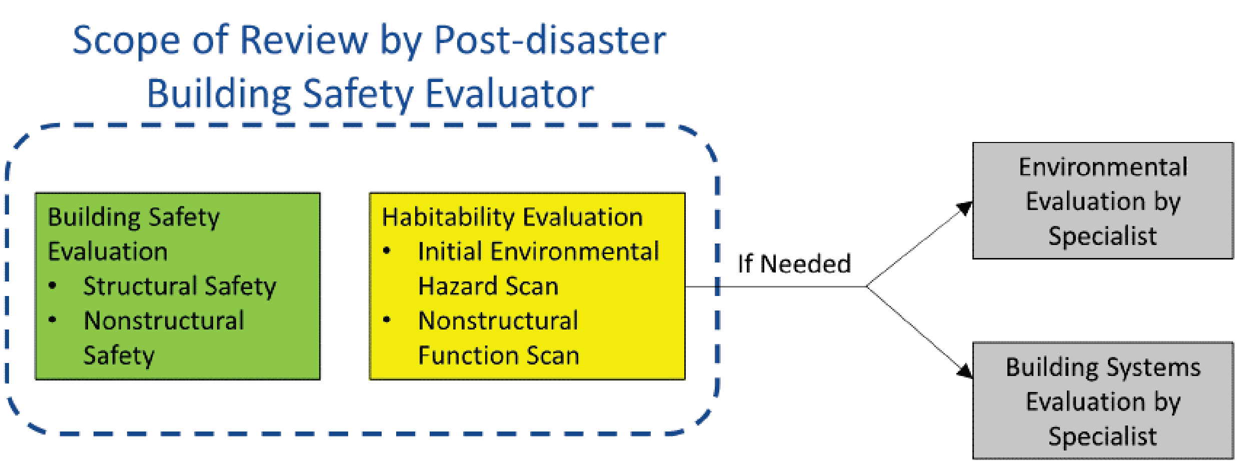


Figure 3-1 Post-disaster framework for building safety evaluation.

As noted in Chapter 2, there are well-established post-disaster evaluation guidelines for earthquake, windstorm, and flood events. Section 3.2 presents guidance for evaluation of earthquake damage based on ATC-20-1, *Field Manual: Procedures for Postearthquake Safety Evaluation of Buildings, Second Edition* (ATC, 2005). Section 3.3 summarizes guidance for windstorms and flood using ATC-45, *Field Manual: Safety Evaluation of Buildings After Wind\storms and Floods*, (ATC, 2004). Section 3.4 covers New Zealand's *Field Guide: Rapid Post Disaster Building Usability Assessment – Geotechnical Assessment* (MBIE, 2017), a newly developed, thorough guide for addressing damage from land instabilities, such as landslides or rock falls that are not necessarily caused by earthquakes.

Sections 3.5 through 3.9 discuss safety evaluation guidance and issues for other incident types such as volcanoes; hail, snow, and ice storms; fire; and explosions. When physical impacts of incidents affect building habitability and building systems, possible consequences are briefly mentioned, and the reader is referred to Chapter 4.

Section 3.10 addresses multi-hazard incidents, such as aftershocks and fires after earthquakes and mudslides or flash floods after wildfires.

Historic buildings and cultural resources can pose challenges for effective safety evaluations given the use of older building materials and the building's cultural significance. Section 3.11 provides associated recommendations for these buildings.

Table 3-1 provides a summary by incident type of best practice guidance, interim recommendations, and additional discussion and needs for structural safety evaluation. Key terms, acronyms, and references are defined within the body of each section.

Table 3-1 Building Safety Evaluation Best Practice Summary

Report Section	Incident Type/ Building Type	Best Practice	Interim Recommendation	Additional Discussion/Needs/Comments
3.2	Earthquake	ATC-20-1, FEMA 306, FEMA 352	Not applicable	• Update ATC-20-1. Add "usability categories," more examples of low and moderate damage, and examples of what not to do. • Develop guidance documents for Engineering Evaluations for building types beyond concrete and masonry walls (FEMA 306) and steel moment frames (FEMA 352).
3.3	Windstorms and Floods	ATC-45	Not applicable	Update ATC-45. Reconsider trigger thresholds; add corner damage criteria, more photos and examples, and tsunami examples.
3.4	Land Instability	New Zealand *Field Guide*	Not applicable	Adapt the New Zealand *Field Guide* to U.S. practice.

Table 3-1 Building Safety Evaluation Best Practice Summary (continued)

Report Section	Incident Type/ Building Type	Best Practice	Interim Recommendation	Additional Discussion/Needs/Comments
3.5	Volcano	None	Use ATC-20-1 and ATC-45	• Use ATC-20-1 for volcano-induced ground shaking, explosive damage from volcanic blasts, damage to roofs from the weight of ash and projectiles, and reduced capacity from structural elements exposed to fire and heat from lava. • ATC-45 is recommended for use in assessing damage from mudflows (lahars) and flooding caused by melting snow. • A volcano-specific field manual should be developed.
3.6	Hail	None	Use ATC-45 and *Composition Roofs Damage Assessment Field Guide*	Add focused section on hail damage to ATC-45.
3.7	Snow and Ice Storms	None	Use ATC-20-1	Need standardized protocol on determining weight of snow.
3.8	Fire	None	Use ATC-20-1	• Develop evaluation methodology specific to fire damage to structural and nonstructural components. • Evaluation of structures following wide-area wildland/urban interface fires and other large-scale fire events.
3.9	Explosion	None	Use ATC-45	Develop evaluation methodology specific to blast loading.
3.10	Multi-hazard Incidents	None	Utilize existing resources to respond.	Build a culture of awareness.
3.11	Historic and Cultural Resources	CalOES *SAP Evaluator Training Manual*	Not applicable	Focus of *Manual* is on earthquake damage. Additional information on damage in other incident types is needed.

3.2 Earthquakes

Earthquake forces can damage structural members of buildings and move them off their foundation. Loss of load-carrying capacity of structural members can cause partial or full collapse of buildings. In addition, damage to nonstructural components due to shaking can cause hazards such as toxic spills or asbestos contamination.

Section 2.2 provides an overview of ATC-20 procedures. ATC-20-1, *Field Manual: Procedures for Postearthquake Safety Evaluation of Buildings, Second Edition* (ATC, 2005) presents the most up-to-date guidance. A training slide set (ATC, 2002), a technical brief concerning earthquake aftershocks and building safety evaluation (ATC, 1999), and a set of case studies (ATC, 1996) are also available as part of the series of ATC-20 documents. Most recently, ATC published ATC-20-1 *Bhutan Field Manual* in 2014, which was developed as an adaptation of ATC-20-1 *Field Manual* to account for Bhutan's vernacular buildings, as well as Bhutan's cultural and governmental context. During the development, a number of improvements were made to the presentation of material in the ATC-20-1 *Field Manual*, including a graphical format with numerous images to help architects, engineers, and building officials evaluate damaged buildings more accurately. Also, the procedures incorporate recent lessons learned during post-earthquake building safety evaluations following the 2010 Maule, Chile Earthquake (2010) and the 2010-2011 Canterbury Earthquake Sequence in New Zealand per ATC-109 (ATC, 2014b). Figure 3-2 shows a timeline of key development points of documents related to ATC-20.

The CUREE EDA-02 report, *General Guidelines for the Assessment and Repair of Earthquake Damage in Residential Woodframe Buildings*, (CUREE, 2010) is a well-regarded document for use by insurance claims adjusters, specific to wood-frame dwellings prevalent in California. At the time of the development of this *Guide*, an update to the EDA-02 report, as well as a complimentary guide for engineers, was under development. These guides supplement the evaluation process, rather than replacing the ATC-20-1 placarding effort. Additional considerations on aftershock probabilities are discussed in Yee and Cornell (2005).

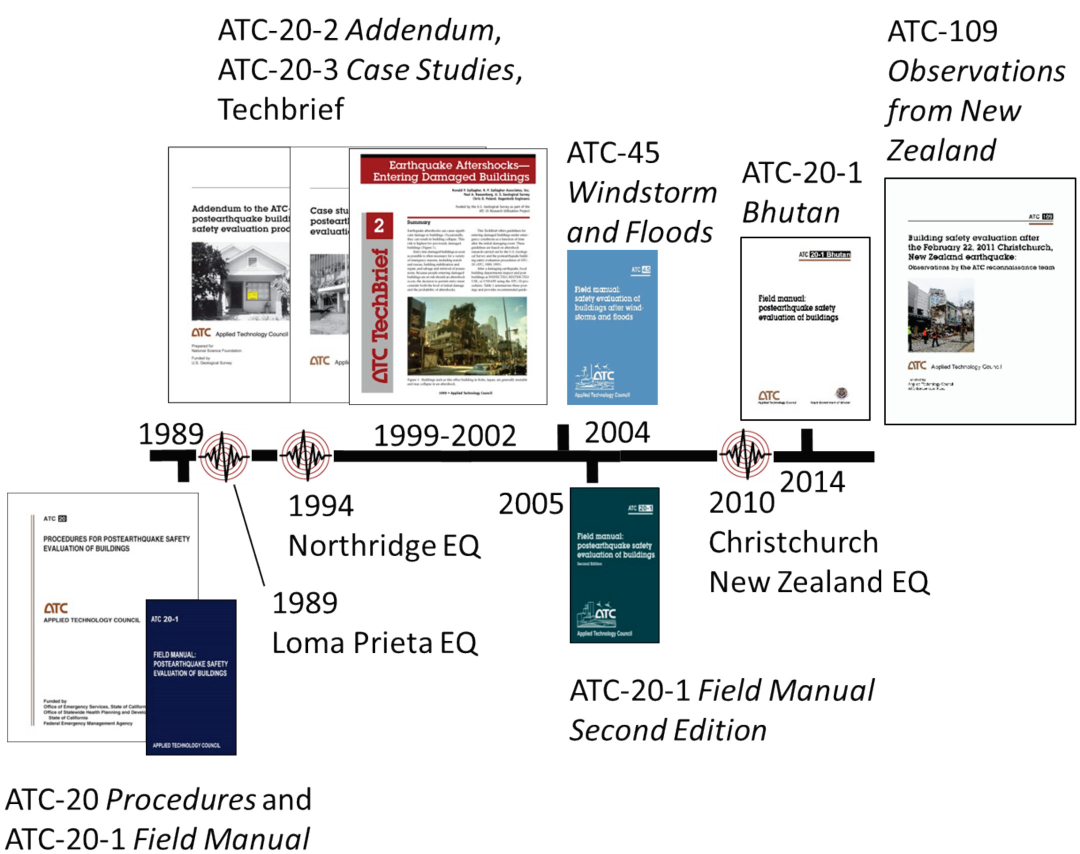


Figure 3-2 Timeline for ATC-20 and ATC-45 development.

Table 3-2 reproduces Table 3-1 in ATC-20-1 that covers the key criteria used in Rapid Evaluations of structural safety and associated posting actions. Case study examples and images are given in ATC-20-1 for each of the six conditions. For Detailed Evaluations, there are individual chapters devoted specific building types, with the damage conditions that commonly occur with the building type and associated placarding recommendations for the condition. ATC-20-1 also has a chapter on evaluation and posting of buildings for nonstructural hazards. Damage to nonstructural components, such as a damaged parapet or canopy, can lead to a RESTRICTED USE placard and a barricade around the unsafe area.

Table 3-2 ATC-20-1 Rapid Evaluation Criteria (from ATC, 2005)

Condition	Action [(1)]
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 [(2)].

(1) In completing the Rapid Evaluation form, the evaluator 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.

(2) RESTRICTED USE posting may be applicable in certain situations.

Best Practice

The current second edition of the ATC-20-1, *Field Manual: Procedures for Postearthquake Safety Evaluation of Buildings*, is recommended for use in evaluating U.S. buildings following earthquakes. ATC-20-1 is used for Rapid Evaluations and Detailed Evaluations. More in-depth evaluations are typically done by consultants hired by the building owner. These are termed Engineering Evaluations in ATC-20-1. Engineering Evaluation guidance is available for select building types in FEMA 352, *Recommended Postearthquake Evaluation and Repair Criteria for Welded Steel Moment-Frame Buildings*, (FEMA, 2000) and FEMA 306, *Evaluation of Earthquake-Damaged Concrete and Masonry Wall Buildings: Basic Procedures* (FEMA, 1998).

Additional Discussion and Needs

ATC has begun the process of updating the ATC-20-1 *Field Manual* to incorporate improvements made in the ATC-20-1 *Bhutan Field Manual*, as well as the New Zealand's *Field Guide: Rapid Post Disaster Building Usability Assessment – Earthquakes* (MBIE, 2014), which incorporated lessons learned from the 2010-2011 Canterbury Earthquake Sequence. Updates are anticipated to include images and examples for both high and low levels of damage, refinements in the evaluation forms, and examples of what not to do.

The New Zealand *Field Guide* and ATC-20-1 *Bhutan Field Manual* both include "usability" categories. Usability categories provide additional information beyond the basic posting category that is helpful for both the building occupants and policy makers dealing with damage evaluation and individual and community-scale recovery (Lizundia et al., 2017). This information can be entered into a database for tracking and also used to provide estimates of damage that are necessary for allocating resources for recovery and reconstruction. Table 3-3 shows the categories used in the ATC-20-1 *Bhutan Field Manual*. They include the distinction made in ATC-20-1 between stable and unstable structures that are posted UNSAFE.

Table 3-3 Usability Category Definitions in the ATC-20-1 *Bhutan Field Manual*

Damage Intensity	Posting	Usability Category
Light damage	INSPECTED (Green)	G1: Occupiable, no immediate further investigation required. G2: Occupiable, repairs may be necessary.
Moderate damage	RESTRICTED USE (Yellow)	Y1: Short-term entry. Y2: Repairs required for safe entry to damaged parts.
Heavy damage	UNSAFE (Red)	R1: Unsafe but stable. Repairs may be possible. R2: Unsafe and unstable. May not be repairable. R3: At risk from adjacent premises or ground failure.

In developing the ATC-20-1 update, questions that may be considered are whether there should be different placards for residential buildings and whether to refine the wording on the placards to provide greater clarity for building occupants. After the 2010-2011 Canterbury Earthquake Sequence in New Zealand, a leaflet was used to help inform occupants regarding building evaluations. Following the 2014 South Napa California Earthquake, the cities of Napa and Vallejo and Napa County published advisories to try to help clarify the meaning of the placards, but they were not consistent with the intent of the ATC-20-1 methodology, specifically regarding the use of the RESTRICTED USE placard. Improved language and guidance on communicating with the public about safety evaluations and placarding are needed. This is discussed in Section 6.11.

FEMA 306 (FEMA, 1998) and FEMA 352 (FEMA, 2000) provide guidance for Engineering Evaluations of concrete and masonry wall buildings and steel moment frame buildings. Additional documents need to be developed to address other building types.

3.3 Windstorms and Floods

ATC-45, *Field Manual: Safety Evaluation of Buildings after Windstorms and Floods,* (ATC, 2004) was published in 2004. The document has been used after damaging wind, flood, hurricane, and tornado incidents in the United States and elsewhere. The document addresses wind incidents, including significant straight-line windstorms and thunderstorms, and cyclonic winds, such as tornadoes and hurricanes. Flood incidents include riverine floods, closed-basin floods, coastal flooding, flash flooding, mudslides, and hurricanes. Hurricanes are combined wind and flood incidents, thus damage from hurricanes is evaluated using the wind evaluation chapter in conjunction with the flood evaluation chapter of ATC-45.

ATC-45 has also been used to evaluate damage from dam breaches. Potential overloading of a building by depositing very large objects on top of a building, or densely packing large amounts of material inside a building, which are phenomena observed in recent extremely large tsunamis and large hurricane surges, were not considered in the development of ATC-45.

Best Practice

The current first edition of the ATC-45 *Field Manual* is recommended for use in evaluating U.S. buildings following wind and flood events. ATC-45 is used for Rapid Evaluations and Detailed Evaluations. More in-depth evaluations are typically done by consultants hired by the building owner. These are termed Engineering Evaluations in ATC-45. ATC-45 provides guidance for evaluation of buildings with small to large amounts of debris coming to rest against a building, or being deposited inside a building through a breach in the building envelope. Depending on the wave height, the size, and the type of debris, which are a function of the location and built environment, ATC-45 may be useful as a post-tsunami building safety evaluation tool.

Additional Discussion and Needs

An update to ATC-45 should consider lessons learned, reconsider trigger thresholds, and add discussion of wind damage at building corners and other discontinuities. The creation of a tsunami chapter would address the excessive loading concerns that this hazard poses. When ATC-45 is updated, the photos and examples should be updated as well.

As noted in Section 3.2 for possible ATC-20-1 updates, improved language and guidance on communicating with the public is also needed. This is discussed in Section 6.11.

3.4 Land Instability

The ATC-20-1 *Field Manual* has a geotechnical section, but it has limited information and lacks specific guidance. New Zealand's *Field Guide: Rapid Post Disaster Building Usability Assessment – Geotechnical Assessment* (MBIE, 2017) is a recent and more comprehensive guide and includes the following features:

- A classification scheme for land instabilities.
- A list of data collection topics specific to land instabilities.
- Evaluation criteria for land instabilities including landslides, boulder roll, cliff collapse, debris flow, lateral spreading, landslide dams, and surface faulting. Figure 3-3 shows examples and definitions for these land instabilities.
- Geotechnical rapid evaluation forms.
- Images of safety equipment.
- List of useful resources.

Land instability can be caused by different hazards and can occur at widely different scales, from those impacting a portion of a building to instabilities that can affect entire neighborhoods. Monitoring of slope movement is often implemented to determine if changes are occurring and their scale. While structural engineers have some general knowledge of geotechnical hazards and can perform some evaluation functions, in more difficult situations, experienced geotechnical professionals are needed.

Best Practice

The 2017 New Zealand *Field Guide – Geotechnical Assessment* is recommended for use instead of the geotechnical chapter in ATC-20-1.

Additional Discussion and Needs

The New Zealand *Field Guide – Geotechnical Assessment* is written to be consistent with the overall current post-disaster evaluation process in New Zealand. Laws, jurisdictional authority, emergency management personnel and procedures, and placards all differ from those used in the United States. It is recommended that a multi-hazard field guide on land instability is developed using the technical approach in the New Zealand *Field Guide* but brought into the U.S. context. Similar to the discussion for ATC-20-1, a U.S. land instability field guide should include more additional images and discussion to better define the transitions between INSPECTED, RESTRICTED USE, and UNSAFE placard evaluations.

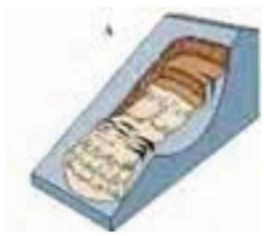
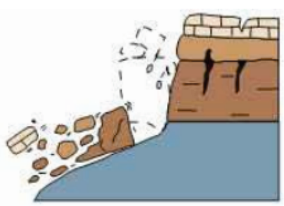
Land stability	Diagram	Description
Landslide (ie mass movement and shallow instability)		A landslide in this context is a downslope movement of a soil or rock mass in either Rotational or translational movement. Rotational slides move along a surface rupture feature within the slope that is curved and concave. For a translational slide, the mass displaces along a planar or undulating surface within the slope.
Boulder roll (rockfall)		Boulder rolls are abrupt, downward movements of individual rocks that detach or are ejected from steep slopes or cliffs. The falling mass may break on impact, may begin rolling on steeper slopes, and may continue until the terrain flattens.
Cliff collapse (rockfall)		A cliff collapse begins with the detachment of soil and/or rock from the cliff, most often along a pre-existing fracture or weakness. The material subsequently descends, mainly by falling, and may break up in flight or on impact and accumulate as a debris wedge or cone at the base of the cliff.
Debris flow		Debris flows are the mobilisation of a mass of material downslope caused by saturation of the material, usually from inundation of a large volume of water. They often descend rapidly and can scour a channel in the slope during descent. The material in a debris flow can consist of soil, rock boulders, timber and other debris.

Figure 3-3 Land instability examples (from MBIE, 2017). Not shown are lateral spreading/differential settlement, subsidence, debris avalanche, slope creep and retaining wall failure.

3.5 Volcanic Eruptions

The main categories of hazards caused by volcanic eruptions are: lava flow, ash (tephra) fall or weight of ash, ash abrasion or corrosion, ground shaking and movement, explosion or blast, and mud flow (lahar) or flooding.

Each of these types of damage can be addressed (in part) by evaluation guides that already exist, e.g., ATC-20-1 and ATC-45. Lava flow incidents can ignite fires and may produce enough heat to impact the integrity of steel or concrete structures. Structures can be impacted by the lateral loading as the lava encounters the structure. Collapse from the weight of an ash fall is a risk. In addition, ash drift can cause localized collapse due to uneven distribution.

Volcanic incidents are frequently accompanied by earthquakes, and damage will be identical to that caused by other seismic incidents. Explosive damage from a volcanic blast (pyroclastic) can be strong enough to level buildings. Flooding, mud flows (lahars), and landslide damage will occur when the volcano is snow covered. Rapid snow melt creates flash floods containing water, mud, and debris.

Figure 3-4 Bridge destroyed by lahar in North Fork Toutle River during eruption of Mount St. Helens, May 18,1980. Source: USGS https://volcanoes.usgs.gov/vhp/lahars.html

Post-disaster evaluators must wait for eruptions to stop in order to safely enter the area. Ash fall may block roads and bridges; lava flows can permanently block roadways; and flooding from lahars can destroy roads and bridges. The ash cloud can ground local aircraft and will impede the use of motor vehicles, as ingestion of ash destroys engines.

Ash will cause abrasion on exterior surfaces of a building and exposed elements. The corrosion of the external elements of the building's heating, ventilation, air-conditioning (HVAC) systems can result in their failure, which may affect the habitability of the structure. At a larger scale, corrosion damage to elements of the electrical grid can occur and can cause widespread outages. Volcanic ash can disrupt or damage components of water supply, treatment, and distribution systems. Local water sourced from lakes or reservoirs can be contaminated by the deposition of ash onto its surface.

Interim Recommendation

No best practice guidance is available for building safety evaluations for volcano incidents. However, ATC-20-1 procedures can be implemented as many of the physical effects of volcano eruptions are similar to those of earthquake loading, including ground shaking induced by the volcano, explosive damage from volcanic blasts, damage to roofs from the weight of ash and projectiles, and reduced capacity from structural elements exposed to fire and heat from lava. ATC-45 is recommended for use in evaluating damage from mudflows (lahars), debris flows, and flooding caused by melting snow.

Preliminary guidance is provided for safety considerations for environmental hazards related to volcano eruptions in Section 4.4.4, *Soot and Fumes*.

Additional Discussion and Needs

A field manual that specifically addresses safety evaluation of buildings following volcanic eruptions needs to be developed. The manual would include:

- Examples of damage from volcano-induced ground shaking and explosive volcanic blasts
- Examples showing roof damage from the weight of ash and projectiles
- Examples of fire and heat damage to structural components from lava
- A section on environmental hazards from volcanoes and safety considerations

Resources

- *Residential Building And Occupant Vulnerability to Tephra Fall*: https://www.nat-hazards-earth-syst-sci.net/5/477/2005/nhess-5-477-2005.html
- *Using Field and Laboratory Approaches to Assess Volcanic Impacts*: https://www.unige.ch/sciences/terre/CERG-C/files/1615/3209/3723/VulnerabilityImpact_T_Wilson.pdf
- *Assessing the Impact from Earthquakes and Volcanoes: What Is Different and What Is Not*: https://www.unige.ch/sciences/terre/CERG-C/files/3615/3209/3566/GEM-L_Martins.pdf

- *USGS Volcanic Ash Impacts and Mitigation*: https://volcanoes.usgs.gov/volcanic_ash/buildings.html
- *Key Facts About Protecting Yourself After a Volcanic Eruption*: https://www.cdc.gov/disasters/volcanoes/after.html
- Wilson, G., Wilson, T., Deligne, N.I., and Cole, J., 2014, "Volcanic hazard impacts to critical infrastructure: A review," *Journal of Volcanology and Geothermal Research*, Vol. 286.

3.6 Hail Storms

Over the past decade, insured losses from hail storms have averaged over $10 billion annually (Bowen, 2018). Although damage to the building envelope can be substantial, hail rarely affects the structural system. Habitability of a structure may be compromised when roof coverings are destroyed and when glazed openings are compromised. Deaths directly associated with hail are rare. It should also be noted that hail storms are frequently associated with strong thunderstorms and tornadoes, and there will likely be a mix of wind and hail damage.

Because hail does not typically result in structural damage or require occupants to vacate buildings, codes and standards do not address this hazard. The insurance and roofing industries have awareness and research knowledge of the impact of this hazard.

Hail impact damage is primarily propagated on:

- Roof coverings
- Building envelopes (cladding)
- Skylights and fenestration
- Outdoor HVAC system components
- Gutters, roof vents, and metal chimneys
- Awnings, canopies, and screen enclosures

Hail one inch and larger in diameter will cause damage to roofing, siding, and glazing. As shown in Figure 3-5, since 2000 about 8.8 percent of hailstorms produced hail in excess of 2 inches in diameter and about one percent of hailstorms in the United States contained hail over 3 inches in size (Childs, 2018). When roof coverings are compromised or glazed openings are breached, water leakage into the structure can occur leading to saturated insulation (decreased performance), mold, rot, and indoor air quality issues. Hail damaged shingles are more susceptible to wind damage. Damage to HVAC equipment will impact the occupant's ability to regulate indoor air temperatures.

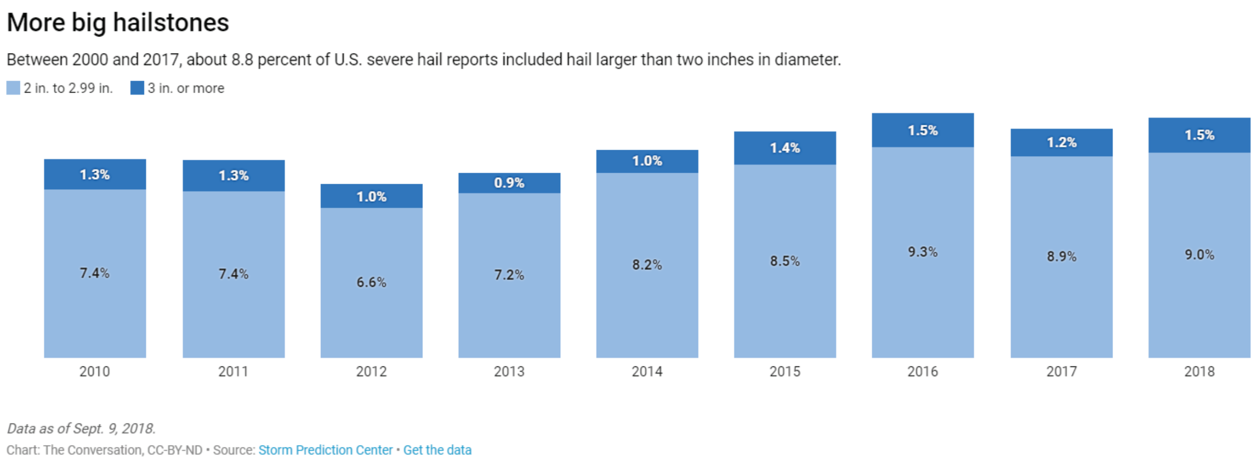


Figure 3-5 Size of hailstones over the years. Graphic source: https://source.colostate.edu/destructive-2018-hail-season-a-sign-of-things-to-come/.

Field guides of hail damage exist in the insurance industry. In 2019, Haag Engineering published the second edition of *Composition Roofs Damage Assessment Field Guide,* which per its title is limited to roof covering damage evaluation.

Interim Recommendation

Until more detailed guidance is added, the current version of ATC-45 for safety evaluation of hail damage (hail storms are accompanied by severe thunderstorms and tornadoes) and *Composition Roofs Damage Assessment Field Guide* (Haag Education, 2019) can both be used.

The ATC-45 *Field Manual* advises evaluators to post a structure with a RESTRICTED USE placard if one or more conditions apply, including:

> *The inspectors are concerned about cladding damage that may result in further damage due to continued exposure to weather conditions.*
>
> *Interior finishes or ceilings are water saturated and may lead to falling hazards or air quality issues.*

The *Composition Roofs Damage Assessment Field Guide* provides advice on evaluating hail damage specific to composition shingle roofs. It notes that it will help "identify and differentiate common conditions found in the field (from manufacturing, installation and weathering anomalies, to hail, wind and mechanical damage)." (Haag Education, 2019)

Hailstorms can cause widespread damage that frequently takes months to remedy due to surge of demand for roofing contractors. This can result in unprotected roofs that leave the interior of structures vulnerable to subsequent rainstorms.

Additional Discussion and Needs

The next edition of ATC-45 should be modified to include a training example of hail damage. The ATC-45 Detailed Evaluation form should also be modified to include a section to note hail damage severity. ATC-45 *Chapter 6 Nonstructural Hazards Table 6-1 Item 3, Cladding* contains evaluation criteria for wind damage (wind-borne debris) that is similar to the damage hail produces (damaged glazing, cladding and connections). Although ATC-45 Table 3-1 in the Rapid Evaluation section speaks to serious falling hazards from "roof or wall cladding damage or missing," it does not mention checking for the integrity of the roof covering. ATC-45 Table 4-1 mentions "roofing damage" as a typical type of damage an evaluator can expect to see. Damaged or missing shingles or underlayment will lead to water infiltration and can impact habitability. On low-rise structures with pitched roofs, the identification of roof covering failures is straightforward and visible from the street. Damage on flat roofs will not be as visible, but they may be at less risk from hail due to the less vulnerable types of material used on flat roofs.

3.7 Snow and Ice Storms

One of most serious winter threats is roof collapse due to the weight of snow and ice. Flat and low slope roofs, or roofs with elevation changes have the highest risk of failure. Roof collapse may also occur due to snow drifting, ponding of snow, ice melt, or from the weight of ice. Even a partial roof collapse can cause extensive property damage, business interruption, and possibly loss of life. Structural damage short of collapse can also occur such as cracked or split rafters and ridge boards. FEMA P-957, *Snow Load Safety Guide*, (FEMA, 2013a) and the one-page accompanying flyer, FEMA *Snow Load Safety Guidance*[1], summarize the warning signs of overstress conditions to structures during a snow incident, key safety issues and risks a snow event poses to buildings, and what to do after a snow incident.

Large storms frequently contain multiple snow incidents, temperatures below freezing, and can be followed by rain accumulations on top of the unmelted snow. Rain falling on accumulated snow can triple the weight of the snow.

Warmer regions of the country may be more susceptible in an unusually severe winter storm, because the roof live load mandated by the building code may be considerably less than the load of a rare storm. For example, in the 1996-97 Christmas week storm in the greater Puget Sound Region of Washington State, loads from heavy snow, coupled with rain, substantially

[1] https://www.fema.gov/media-library-data/1392984631969-ac57339deb6ee839a52b16b01eeee53e/FEMA_Snow_Load_508.pdf

exceeded the roof live loads and relatively low snow loads specified for design, and this was one of the causes leading to the collapse of 1,800 roofs (FEMA and SEAW, 1998).

Significant, larger-than-usual winter storms can damage trees, power lines, and cell towers causing damage to structures, widespread interruption of electrical service, and communication system failures.

These events can limit travel in the community due to road closures, and ice dams and jams on rivers can cause severe local flooding. Power outages can cause inhabitants to rely on alternate heating sources or the use of portable generators which have, in the past, led to structure fires as well as illnesses and deaths due to unintentional carbon monoxide (CO) poisoning. Power outages can also lead to frozen water in potable water pipes and fire suppression pipes.

Falling or sliding snow and ice masses can block building exits; damage portions of structures such as eaves, rakes, canopies, awnings, porches, decks, gutters; and create falling hazards on stairs and sidewalks. Snow cornices and large icicles can present falling hazards, especially at building entries or sidewalks adjacent to buildings. Uncommonly large accumulations of snow and ice can block mechanical units and roof top vents, leading to carbon monoxide poisoning of occupants. Creation of ice dams on roofs can cause roof collapse and interior water leaks which can create mold or indoor air quality problems.

Ice storms are particularly dangerous. Ice accumulation damages trees, snaps power poles and lines, and can cause the collapse of high voltage power line towers and cell towers. Tree failures will block roads, can cause structural damage to light frame construction and water damage, and can take down power lines creating widespread electrical power outages and communication system failures. As little as a half-inch of ice is enough to break tree limbs. Falling tree limbs have damaged roofs and pulled electrical lines or masts off of buildings, causing additional power outages.

Accurate assessment of the weight of snow is important for safety evaluations regarding potential roof collapse. The weight of snow is difficult to estimate visually because loading must be calculated by determining the water content per unit of thickness, but snow density varies substantially depending on location. In addition, uneven distribution of snow caused by drifting, thawing, and refreezing of snow as ice, shielding of part of a roof from the sun by adjacent structures, or the accumulation of snow and ice on flat roofs, make it difficult to estimate the thickness of snow.

In past incidents, accumulated weights were taken from National Weather Service (NWS) snow/rain gages in open areas, or local storm reports. NWS instruments, sampling procedures, and collection times are not standardized between weather stations, and local reporters do not have a standardized sampling procedure. These sampling procedures do not capture the unbalanced weight of drifting snow, the accumulated weight of rain on snow, or the buildup of weight caused by plugged roof drains. Additionally, snow fall is not uniform; some areas may receive more snow than what may be measured at an official weather station. This means that on-site measurements of weight of snow are necessary.

Interim Recommendation

Until more detailed guidance is developed, ATC-20-1 procedures can be used for safety evaluation of snow and ice storm damage, primarily roof structural safety. Examples include: an UNSAFE placard for roof collapses, a RESTRICTED USE placard for partial roof collapses, broken eaves or roof rakes, and a RESTRICTED USE placard (with an associated barricade) for potential sliding snow and ice masses.

Additional Discussion and Needs

Cases where an Authority Having Jurisdiction (AHJ) has had to mobilize evaluators after snow and ice incidents have been anecdotally reported but not well documented. Procedures that local officials could utilize to assess the potential impact of approaching storms should be developed.

A safety evaluation guide specific to snow and ice storm incidents should be created. Such a guide would enable volunteers to evaluate damage and provide a consistent basis for posting to ensure occupancy. The guide should also include training on determining the weight of local snow and ice accumulation in order to determine if the weight of snow and ice exceeds local code design parameters.

Standardized snow and ice sampling and data collection procedures are also needed. Sampling is currently being undertaken by the NWS, local news or weather reporters, and individual engineering and architectural firms. The standardized data collection method needs to be known and available to any entity who might need to collect these data. Once the equivalent water density is known, along with variations of the density within a region, measurements of snow depth on structures can be easily converted to the weight of the snow on those structures. It is important that the sampling method be able to determine the loads on roofs during, or very quickly after, the incident to provide owners and their engineers sufficient data to make snow removal decisions.

Resources

- *Snow Load Safety Guidance*: https://www.fema.gov/media-library-data/1392984631969-ac57339deb6ee839a52b16b01eeee53e/FEMA_Snow_Load_508.pdf
- FEMA P-957, *Snow Load Safety Guide*: https://www.fema.gov/media-library/assets/documents/83501
- *Considerations for Building Design in Cold Climates*: https://www.wbdg.org/resources/considerations-building-design-cold-climates
- *Minimizing the Adverse Effects of Snow and Ice on Roofs*: https://www.poa.usace.army.mil/Portals/34/docs/engineering/MP-01-5663,%20Minimizing%20the%20Adverse%20Effects%20of%20Snow%20and%20Ice%20on%20Roofs.pdf
- *Risk Control Bulletin: The Snow Loading and Roof Collapse Preparation Guide*: https://www.cna.com/web/wcm/connect/724b4890-896c-461d-b896-b21ba1c1faf9/RC_Property_BUL_SnowLoadingandRoofCollapse_CNA.pdf?MOD=AJPERES

3.8 Fire

Building safety evaluations following fire can be performed utilizing most of the same methodologies defined in ATC-20-1 for identification of structural deformation when initial triage and evaluations commence.

Fire incidents can be localized to a single building or affect a wide region such as wildfire. It has often been observed following wildfire incidents that some structures are burned so badly as to be essentially destroyed while others may be untouched simply because of the fire's path. When a wood-frame structure has burned to the ground, but its unreinforced masonry chimney remains, the AHJ may choose to apply a RESTRICTED USE placard because of the falling hazard the chimney poses.

The broader issue, though, is the evaluation of structures with partial fire damage to structural members to determine whether they are safe to reoccupy. Qualitative (or quantitative, if possible) evaluation of section loss of charred members can be performed to establish a relative level of degradation of member capacity and resultant structural deficiency.

Detailed evaluation of structures impacted by fire can utilize the vast body of knowledge now available to design professionals engaged in the performance-based design of these types of structures. Published guidelines for the detailed quantitative-based analysis of structural members including wood, steel, and concrete exposed to fire include *Structural Fire Engineering* (ASCE, 2018), *Calculating the Fire Resistance of Wood Members and Assemblies* (AWC, 2018*), Structural Design for Fire Safety* (Buchanan and Abu, 2017), and *Engineering Guide: Fire Exposure to Structural Elements* (SFPE, 2004).

However, rapid evaluations lack an effective methodology for determining when the fire exposure of an intact structural element is a concern. For example, the effects of heat from fire on wood members may cause degradation that is not always readily apparent, such as metal truss plate connecters that can be significantly impacted by exposure to heat without any significant visible charring of the wood.

Lastly, one unique aspect of post-fire building evaluations is possible exposure of evaluators to latent chemical hazards from products of combustion. See Section 6.3 for more information regarding this topic.

Interim Recommendation

No best practice guidance exists for fire damage. In the interim, ATC-20-1 procedures can be used for safety evaluation of fire damage until more detailed guidance is developed for specific structural and nonstructural hazards associated with fire incidents. It is recommended that the Detailed Evaluation criteria of ATC-20-1 for structural and nonstructural hazards be utilized for these evaluations. The categories listed on the ATC-20-1 Detailed Evaluation form provide appropriate guidance and direction to identify hazards that are associated with typical fire incidents (single structure or wildland fires).

Additional Discussion and Needs

A key question for the evaluation is whether fire damage has sufficiently weakened the vertical load-carrying or lateral force-resisting capacity of structural elements. If the building is leaning because of compromised components from the fire damage, the ATC-20-1 criteria can be applied in a fairly straightforward manner. When applying ATC-20-1 criteria in a post-fire evaluation, the evaluator must consider the *intent* of the damage category, and not just look for the specific conditions set forth in the ATC-20-1 checklist. For example, if a plywood shear wall has burned, then the decision on whether to apply a RESTRICTED USE or UNSAFE placard will depend on the extent and severity of the amount of fire damage to the wall components and their continued ability to resist vertical and lateral loads as required by building code-specified critera. With regard to the secondary events, ATC-45 presents a narrative regarding secondary events (the discusion in ATC-20-1 is focused on aftershocks). As the probability of a second extreme loading event is low following a fire, this less conservative approach can be implemented.

Methodologies and guidance are also required for the triage and evaluation of structures following wide-area wildland/urban interface fires and other large-scale fire events. Such guidance should include both structural and nonstructural ramifications of such fire exposure, including effects of adjacent structures.

In addition, development of a flowchart-based decision tree may assist evaluators with the visual analysis of fire-exposed intact wood members. A good example is in Kirby et al. (1986).

Resources

- CIB, 1989, *Repairability of Fire Damaged Structures, Report 111*, CIB W14, Conseil International du Batiment, Fire Commission.
- SEAOC, 2019, *Structural Engineering Bulletin: Post Wildfire Site Investigations*, Structural Engineers Association of California, SEAOC Ad-hoc Wildfire Committee, May.

3.9 Explosion

Explosions generate pressures that are typically greater than any of the loading considered in the design criteria of typical buildings and structures, albeit at significantly shorter durations. As a result, most structures in close proximity to a blast incident are significantly affected by the air blast and pressure waves associated with a detonation. These waves manifest as both positive and negative pressures on a structure and as a result can cause effects that are dissimilar to most typical loading scenarios.

Proximity to the blast typically determines the effects on a structure. Explosions that are located close to the building generally result in high impulse, high intensity pressures to a localized portion of the building. Explosions farther away from a building usually produce lower intensity, but longer duration uniform pressure over the entire structure. Structures exposed to blast loading are typically subject to membrane or bending type failures. Shear failures of primary members also result from these exposures.

A unique aspect of explosions is that some explosions are followed by large fires, whereas some may not have any fire at all (dust explosion). Low explosives, such as fuels and gunpowder, typically create large fires following their detonation. High explosives, such as TNT, nitroglycerin, and the various compounds that make up Semtex and C4 ‘plastic’ explosives, typically do not result in large fires due to their very rapid rate of deflagration.

For structures affected by fire following an explosion, criteria in this section as well as the recommendation in Section 3.8 (Fire) are applicable.

Another unique aspect of blast loading is the negative bending (uplift) forces that are typically applied to horizontal members and floor systems when subjected to pressures that enter through a damaged building envelope in a blast. Many structures are typically designed without consideration for this type of loading. As a result, the negative bending can cause disproportionate failure of such members exposed to blast.

In addition, there may also be nonstructural effects of blasts that should be considered. These include, but are not limited to:

- Shattered glass/debris
- Racked door openings
- Resultant contamination from the explosion and/or building contents
- Damage to mechanical, electrical, and plumbing systems resulting from overpressure
- Damage to the building exterior envelope caused by the heat of the blast

Interim Recommendation

Similar to the recommendations for fire incidents, structures affected by explosion can be evaluated utilizing existing criteria in ATC documents until such time as a detailed guidance document is developed.

The ATC-45 Detailed Evaluation procedures are appropriate for most post-blast evaluations. Accordingly, ATC-45 was used to evaluate buildings in Bozeman, Montana after a 2009 explosion and in Seattle after a 2016 gas line explosion. As noted in Section 3.8, the categories/types and *intent* of the damage conditions listed in the ATC-45 checklist need to be utilized by the evaluator in determining the components and systems to be evaluated in a post-explosion environment. Damage to gravity and lateral system components are likely due to the blunt force of air blast pressure, as well as the shattering effects (brisance) of the detonation. Consideration of such global and local instabilities must be considered by the evaluator.

Further, nonstructural hazards created by the brisance effects of explosions need to be considered. Such conditions include falling hazards from shattered windows, glass, and other brittle materials such as masonry veneer.

Since the probability of a second extreme loading event is generally low following an explosion (with the exception of intentionally placed explosions), a less conservative approach can be implemented when considering the effects of secondary loading events during a post-explosion evaluation.

Additional Discussion and Needs

Due to the unique nature of damage caused by explosions (further complicated by the varying compositions of the detonating material and stand-off distance), it is recommended that a guidance document be developed to address post-blast safety evaluation of structures. Such a document can likely be developed based on information contained within existing publications.

3.10 Multi-hazard Incidents

Most incidents are inherently complex with widespread impacts to communities, infrastructure, the natural environment, and society. The complexity increases when the initial incident is followed by a related and yet unique incident which, in and of itself, generates a different type of damage that will need to be properly evaluated.

Multi-hazard incidents can occur simultaneously, such as a hurricane that combines windstorms and floods, as secondary incidents that are started by a primary incident as a direct cause, such as a fire that occurs after an earthquake, or as cascading incidents that occur as a direct or indirect result of an initial incident with an effect that can be crippling to a community (FEMA, 2013b). While direct damage is caused immediately by an incident itself, indirect effects usually involve interruptions to a functional use. For example, when a sewer treatment plant is washed out due to a flood, the habitability of homes in the community is impacted.

In a multi-hazard incident, the secondary incident may be small and limited in scope or may be more widespread and destructive than the primary incident. The secondary incident may occur seemingly simultaneously, such as an earthquake-induced tsunami, or not for weeks or months later, such as mudslides and flash floods after wildfires. Fires may also ignite with delay following an initial incident due to hidden mechanical or electrical issues than go unnoticed until power is reestablished at a structure. Secondary incidents may impact the population but may not necessarily lead to the need to evaluate structures.

The following are some examples of primary and secondary incidents and their potential impacts:

- A primary incident at a nuclear power plant supporting the region could cause a widespread power outage in the region. If this occurred during a mid-summer heat wave, it would prove devastating to the area’s inhabitants but would not likely precipitate the call for safety evaluations of structures.

- An ice storm (primary incident), may cause a widespread power outage due to the collapses from the weight of ice on low-slope roofs, and a tendency of ice-covered electrical service conductors to be pulled off the side of homes. This lack of power can lead to freezing and bursting of water supply lines and water damage (secondary incident) inside homes.
- Flooding may stress dams and levees causing them to fail (primary incident) leading to inundation (secondary incident) and impacts to structures.

When an incident occurs, one of the first considerations should be to evaluate the potential for secondary and cascading events to occur. It is important to establish safety protocols for teams in the field to ensure their safety. In addition, understanding the damage potential of the secondary incident will be critical in the safety evaluation process.

The following are examples of multi-hazard incidents in recent history:

- **2017 California wildfires leading to mudslides.** In December 2017, the Thomas Fire in Ventura and Santa Barbara Counties burned approximately 280,000 acres (Cal Fire, 2019). This event was followed a month later by a rainstorm. The charred hillsides were exceptionally vulnerable to landslides and flooding. In January 2018, a debris flow in Montecito and Carpinteria within the Thomas Fire burn area led to 23 deaths and injured more than 160 (County of Santa Barbara, 2018). The debris flow probably would not have occurred had the wildfire not destroyed the vegetation that stabilized the hills. In addition to the homes that were damaged or destroyed by the mud, the debris flow also caused a gas main explosion. This would also be considered a cascading or secondary event. The explosion burned several homes.
- **2010-2011 Canterbury Earthquake Sequence leading to cliff collapse, rock fall, landslides, and flooding.** On February 22, 2011 a magnitude-6.2 earthquake occurred in Christchurch, New Zealand, damaging buildings and infrastructure already weakened by the magnitude-7.1 Canterbury earthquake of September 4, 2010. In response, New Zealand instituted a number of restricted entry zones due to the potential for secondary or cascading events. In the Central Business District, the major concern was due to unstable structures that might collapse in an aftershock. In the eastern suburbs, the Residential Red Zone was established for land that is subject to liquefaction or the related effect of lateral spreading and that was deemed uneconomic to repair. In the Port Hills, a Residential Red Zone was created to address buildings damaged or at future risk from rock fall or cliff collapse.

Liquefaction, lateral spreading, and earthquake-related subsidence altered the capacity of rivers and the topography, subsequently increasing the risk of flooding in some parts of the city (Potter et al., 2015).

- **1989 Loma Prieta Earthquake, San Francisco, California leading to fires .** The magnitude-6.9 Loma Prieta earthquake caused 63 deaths and 3,757 injuries. Fires occurred as the result of a variety of causes. In the Marina District, four buildings were destroyed by fire. A natural gas main in the district ruptured causing a major structure fire which was exacerbated because the nearby hydrant system failed. Other fires were caused by damage to electrical wiring or electrical equipment, overturned or disrupted appliances, and several isolated causes (Mohammadi et al., 1992).
- **1995 Kobe, Japan Earthquake leading to fires.** The magnitude-6.9 earthquake in Kobe, Japan, resulted in hundreds of fires, and automobile congestion and debris blockage of many streets. The city had just under a thousand 40,000-gallon capacity cisterns and thirty water reservoirs, 22 of which had seismic shut off valves to conserve water for firefighting. While the valves worked, massive damage to underground piping systems and road congestion made access to the reservoirs difficult. The combined underground water system was depleted in just a few hours. The fires destroyed between 5,500 to 6,900 buildings (Chung, 1996).

Interim Recommendation

Existing resources (trained safety evaluation personnel, protocols, guides, and tools) can be utilized to respond to multi-hazard incidents as each event occurs. As much as practical, a methodology to anticipate the potential for these secondary incidents should be developed. Creation of a culture of awareness within the response community that acknowledges that the primary incident may not be the only event nor may it be the most destructive or impactful would be beneficial.

Additional Discussion and Needs

Guidance should be developed to categorize the types of secondary and cascading incidents that have the potential to impact an area after a specific primary incident. Training of incident management personnel should address likely incidents for which the deployment of rapid evaluation personnel may be required, in order to create an awareness to the potential risk and need for additional assets. Timing of the secondary incident will impact the ability of inhabitants to safely reoccupy their homes.

A universal framework for addressing cascading disasters is missing from current practices. Figure 3-6 provides a start to understanding the relationships between primary and secondary incidents (called hazards in the figure), as provided in *Seattle Hazard Identification and Vulnerability Analysis* (Seattle, 2019a). Note that not all of the primary incident types listed are ones that would result in the deployment of a safety evaluation team (e.g., disease outbreak).

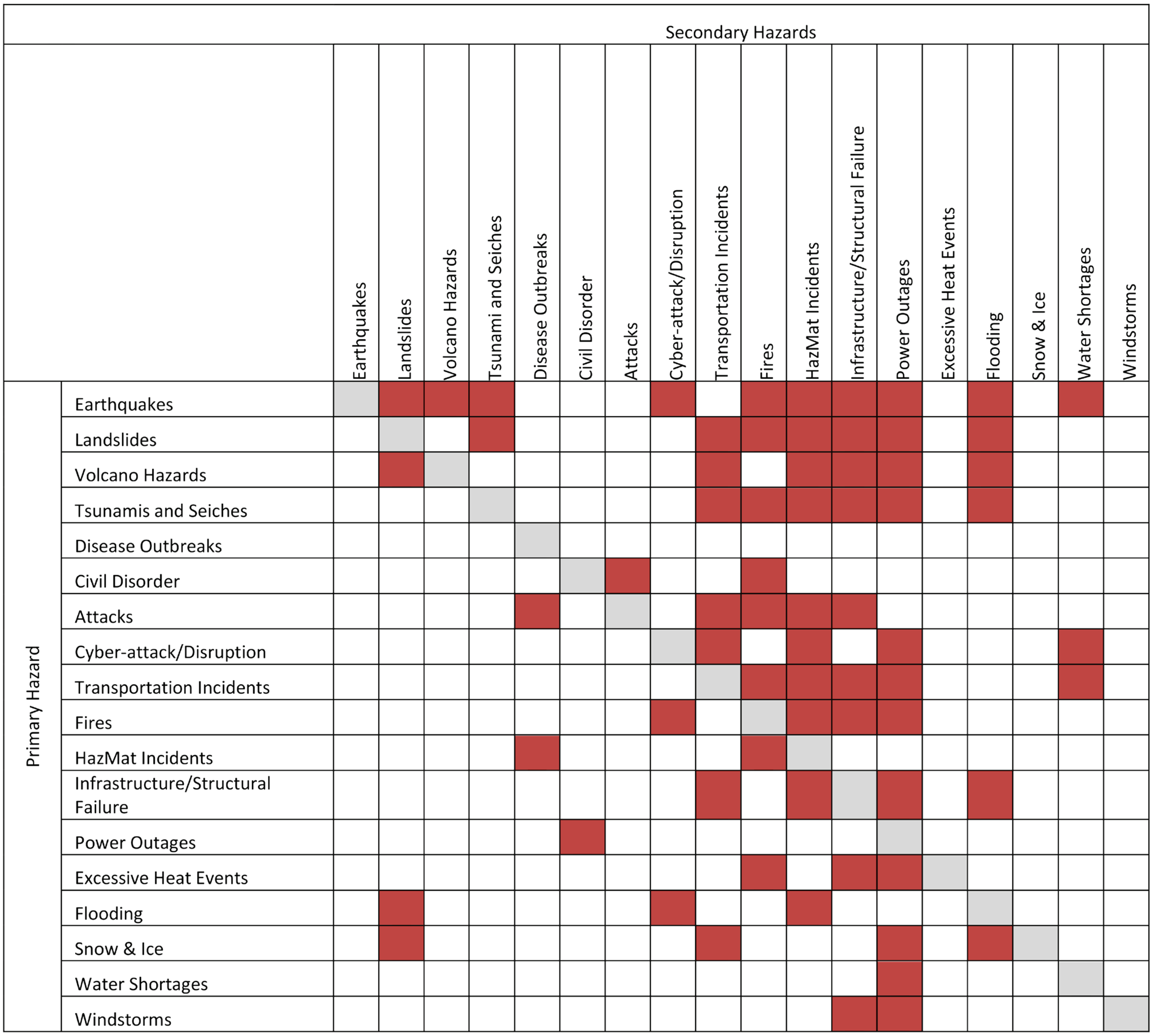


Figure 3-6 Relationships of primary and secondary hazards (Seattle, 2019a).

The following excerpt describes the Figure 3-6:

This table shows the relationships between primary hazards (left) and secondary hazards (top) (i.e., cascading effects). A secondary hazard is one that can be triggered by the primary hazard (red boxes). A triggered hazard has its own secondary hazards. These are tertiary hazards. For example, a snow storm occurs. This is the primary hazard. Then it *rapidly melts triggering urban flooding and landslides. These are the secondary hazards. The landslides knock out the supports of a bridge that also carries power, water and gas lines. These outages are the tertiary hazards. These cascading effects can have a huge multiplier effect and make the effects of hazards hard to predict. They are one of the major reasons it is a mistake to equate hazard vulnerability with disaster vulnerability.*

Resources

- May, F., 2007, *Cascading Disaster Models in Postburn Flash Flood*, USDA Forest Service Proceedings RMRS-P-46CD. Available at: https://www.fs.fed.us/rm/pubs/rmrs_p046/rmrs_p046_443_464.pdf
- AghaKouchak, A., 2018, "How do natural hazards cascade to cause disasters?", *Nature, International Journal of Science*, September.

3.11 Evaluation of Historic and Cultural Resources

Buildings that have cultural and historic significance may provide unique challenges for post-disaster evaluations.

The *National Historic Preservation Act* (NHPA) of 1966 authorized the *National Register for Historic Places*[2], the official list maintained by the National Park Service of buildings, districts, sites, structures, and objects worthy of preservation. Although many historic properties may be eligible for or already listed on the National Register, the lack of eligibility or listing does not necessarily mean a property is insignificant. Typically, any property 50 years or older may have potential historic significance, but a formal assessment of the property's significance requires consultation with the State Historic Preservation Officer (SHPO) or Tribal Historic Preservation Officer (THPO), the official in a state or tribal historical or environmental agency.

Additionally, while a structure may not be listed on the National Register, it may be a designated historic structure on a state or local register. Cultural resources consist of the physical evidence or place of past human activity such as a specific site, object, landscape, or structure. Objects or natural features of significance to a group of people traditionally associated with them are also considered cultural resources. Culturally valued resources include historic properties, other pieces of real property (monuments, statues, sculpture, etc.), and the cultural use of the biophysical environment (sacred places). Historic structures and cultural resources may be unique in their

[2] https://www.nps.gov/subjects/nationalregister/index.htm

construction and may include novel and innovative (for the time) structural and decorative elements. Thus, conclusive Rapid Evaluations may be difficult for these structures and objects. An example would be the 2011 earthquake damage to the Washington Monument. Its value as a cultural resource and its location in a highly populated area mandated that the damage be evaluated. The size and the complexity of its construction necessitated a Detailed Evaluation and the engagement of a forensics engineering firm.

Due to the historic nature of the structure, the owner may be willing to undertake extensive repairs or renovations in order to preserve the historic integrity of the property. Individual states may acknowledge these efforts through the enactment of specific code exemptions for historic structures that are not available for newer buildings. It is noted that repairs of the damage to a historic building may trigger compliance with accessibility requirements (see Section 4.6.3 for a discussion of accessibility).

The California Governor's Office of Emergency Services (Cal OES) *Post-Disaster Safety Assessment Program (SAP) Evaluator Training Manual*, (Cal OES, 2016a) *Unit 3 Building Evaluation, Section 3.3 Historic Structures* provides guidance on assessing damage to historic buildings. This guidance includes contacting the SHPO/THPO to help determine the historic value of a structure, cautions regarding assumptions on materials and techniques that may have used at the time of construction, and a clarification that the UNSAFE placard is not a demolition order.

The Minnesota Department of Administration State Historic Preservation Office's *Historic and Architectural Survey Manual* (Minnesota, 2019) offers the following guidance to provide information and assistance to owners of historic properties, local governments, and disaster evaluation and relief personnel when historic buildings, sites, or archaeological sites are vulnerable to or have been damaged by a natural disaster:

> *After a disaster is a time for carefully planned efforts to rebuild for the future. Building assessment teams may include FEMA inspectors who are NHPA Section 106 historic property reviewers as well as local and regional building officials. These teams also should include professionals with historic building expertise when historic properties are involved. General guidelines that should be considered during the recovery period following a disaster include:*
>
> - *Take it slow! Allow time to properly evaluate damage before making decisions that are irreversible. Too often buildings are torn down before historic preservation solutions have been explored. "Red*

Tags" do not mean that the building must be torn down but that the building is not currently safe for occupancy.

- *Do not allow any materials to be removed from the site until you and professionals with historic building experience have evaluated what materials should be salvaged. Some decorative elements may not be salvageable for reuse but can provide patterns for reconstruction.*
- *Make certain that damage to historic structures is evaluated by architects, engineers, and building officials who are familiar with historic building methods and materials.*
- *Document damage to historic buildings with photographs prior to any activity.*
- *Consult the SHPO whenever damage has occurred to historic buildings.*
- *Use the Secretary of the Interior's Standards for Rehabilitation as your guide in rehabilitating historic properties damaged in a disaster. Information is available from the SHPO.*

While the Cal OES *SAP Evaluator Training Manual* notes that "in some cases, the only way to address extreme danger is to demolish the building, many buildings, or portions of them, can be stabilized to reduce the imminent hazard." It is the responsibility of the local building department to take action, when necessary, to protect adjacent properties or the public right of way through requirements for immediate stabilization or even demolition, of historic structures. That said, making recommendations for stabilization is not a primary function of the safety evaluation process.

Best Practice

The Cal OES *SAP Evaluator Training Manual* provides guidance on evaluating historic structures; however, the included scenarios are all examples of seismic damage for use following an earthquake event.

The Minnesota Department of Administration State Historic Preservation Office's *Historic and Architectural Survey Manual* provides evaluation guidelines for wind, flood, fire, snow, and ice damage to historic buildings, as well as the general guidelines for consideration during the recovery period following a disaster. Where applicable, the THPO should be substituted for the SHPO.

Additional Discussion and Needs

Specific guidance for evaluating historic and cultural resources should be developed and include consideration of archaic materials. It is recommended that additional information similar to Cal OES *SAP Evaluator Training Manual Unit 3 Building Evaluation, Section 3.3 Historic Structures* be developed for the evaluation of historic structures damaged by other hazards.

Preservation experts and SHPOs/THPOs should be engaged in creating recommendations specific to hazard, risk, and construction methodology at a given site for future evaluation efforts. Issues to consider include the following:

- Archaic materials still have capacity, even if they do not meet current detailing and material strength standards.
- Post-disaster safety evaluation focuses on whether there has been a significant change in the capacity of the structural system. Historic buildings may have less capacity than modern buildings, but an UNSAFE or a RESTRICTED USE posting requires that the strength, stiffness, or stability of the building has been reduced such that the building is sufficiently less safe than before the incident to warrant limitations being placed on occupancy.
- An UNSAFE placard does not mean the building must be demolished. In some past incidents, damage to historic buildings has been used as an opportunity to demolish them. The statement "This is not a demolition order" was added to the UNSAFE placard to help prevent misunderstandings and misuse of the placard.
- Stabilization measures for damaged historic buildings and archaic materials can require more sensitivity and care than other buildings to protect historic finishes, while still providing the appropriate level of safety.

Resources

- *National Historic Preservation Act of 1966*: https://www.nps.gov/history/local-law/nhpa1966.htm
- FEMA P-1024, *Performance of Buildings and Nonstructural Components in the 2014 South Napa Earthquake*, prepared by the Applied Technology Council for the Federal Emergency Management Agency, Washington, D.C.
- FEMA P-942, *Hurricane Sandy in New Jersey and New York Mitigation Assessment Team Report*, *Chapter 6: Historic Properties*: https://www.fema.gov/media-library-data/1385587460719-189d039332273d129170ea2cabe30542/Sandy_MAT_Ch6_508post.pdf

- FEMA 549, *Hurricane Katrina in the Gulf Coast Mitigation Assessment Team Report: Chapter 6: Historic Buildings*: https://www.fema.gov/media-library-data/20130726-1520-20490-0003/549_ch6.pdf
- *California Historical Building Code, California Code of Regulations Title 24, Part 8 Alternative Regulations for Qualified Historical Buildings*: https://codes.iccsafe.org/content/chapter/2342/
- *International Existing Building Code*, International Code Council
- *Secretary of the Interior's Standards for Rehabilitation*: https://www.nps.gov/tps/standards/rehabilitation/rehab/stand.htm
- *ADA Accessibility Guidelines (ADAAG), 4.1.7 Accessible Buildings*: *Historic Preservation*: https://www.access-board.gov/guidelines-and-standards/buildings-and-sites/about-the-ada-standards/background/adaag
- *Disaster Response and Recovery Guides*: https://www.culturalheritage.org/resources/emergencies/disaster-response-recovery

Chapter 4

Habitability Evaluation and Other Considerations

4.1 Overview

Even if the structural and nonstructural systems of a building have not been significantly damaged and do not pose a safety risk per Chapter 3, occupancy may be compromised by other forms of nonstructural damage, environmental hazards, and a lack of necessary services. This chapter presents guidance and discussion on issues that may impact habitability and expands upon the limited habitability evaluation guidance provided in ATC-20-1 and ATC-45, such as environmental scans related to downed power lines and gas leaks. The chapter concludes with a discussion of considerations in developing temporary habitability standards for occupancy of buildings as repairs are completed and necessary services are restored.

The concept of habitability is already considered in some FEMA policies and practices, as summarized in Section 4.2. The FEMA *Individual Assistance Program and Policy Guide* (FEMA, 2019c), which addresses residential buildings, defines "habitable" as safe, sanitary, and functional where:

- "Safe" refers to being secure from disaster-caused hazards or threats to occupants.
- "Sanitary" refers to being free of disaster-caused health hazards.
- "Functional" refers to an item or home capable of being used for its intended purpose.

Note that "functional" as used by FEMA (2019c) simply means that the structure can serve as a residence. Assistance cannot be used to convert the structure to a new use, and "functional" does not explicitly mean that all systems and services within it are operational.

In this *Guide*, habitable means the building is occupiable, and it applies to not just to residences but also to other types of buildings, such as offices, schools, and stores. This chapter explores the concepts underlying the FEMA definition of habitability in detail as they relate to reoccupancy following an incident.

Section 4.3 describes approaches to habitability evaluation including chronology of assessing environmental hazards, disaster-induced building system and code deficiency evaluations, and the necessary evaluator skills.

Figure 4-1 shows an overview of the issues that are covered in Section 4.4 through Section 4.6.

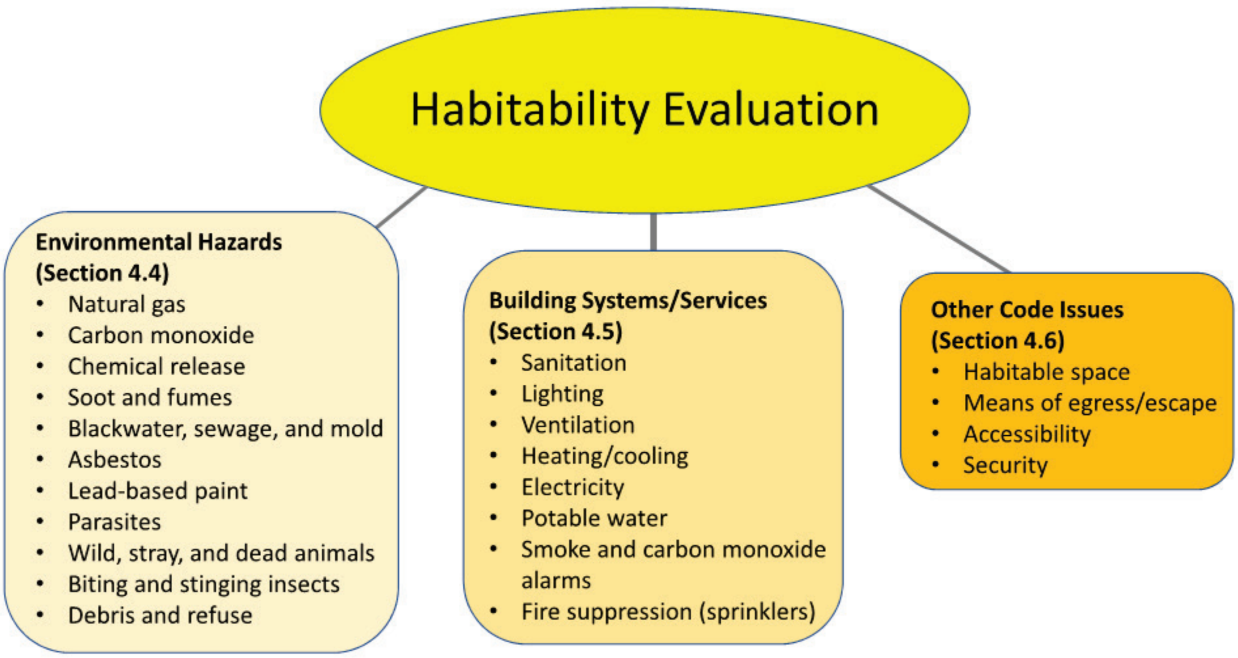


Figure 4-1 Habitability evaluation topics.

Incidents can increase exposure to gas, carbon monoxide, hazardous chemicals, soot and fumes, mold, sewage, asbestos, lead, communicable diseases, and other environmental hazards. Section 4.4 describes the nature of these hazards and how to evaluate them to determine if continued occupancy is acceptable.

Building codes have requirements related to repairs for damaged buildings, discussed in Sections 2.5 and 6.9. Building codes and laws also establish requirements for occupancy and habitability for new and existing buildings based on key services and features of buildings, including: sanitation, lighting, ventilation, heating and cooling, electricity, potable water; fire alarm, carbon monoxide alarm, and fire suppression services; the amount of necessary habitable space; means of egress and emergency escape requirements; requirements for persons with disabilities, or access and functional needs and seniors; and security and personal protection. Building codes are considered as minimum requirements for new and existing buildings that have not been subjected to the effects of a disaster. Section 4.5

and Section 4.6 summarize minimum requirements and whether there are temporary requirements following a disaster. The focus of Section 4.5 and Section 4.6 is on residential buildings; Section 4.7 discusses how requirements change for non-residential occupancy types.

Allowing residents to remain in their homes until necessary repairs can be made or services restored can minimize the need for temporary shelter and help accelerate household and community recovery. Section 4.8 presents issues to consider when developing a framework for temporary habitability standards that may allow post-disaster interim use of residential buildings. An underlying assumption is that the standards that apply to permanent occupancy do not necessarily need to fully apply in the immediate aftermath of an incident. The key question, then, is what are the minimum requirements that should apply? Section 4.8 also provides examples of temporary habitability standards, key questions that need to be addressed in developing temporary standards, and approach options for implementation. The focus is on identifying issues and options to help communities develop policies for a temporary habitability standard that permits lower standards and is flexible so that communities can adapt it to their specific situations. Temporary habitability concepts in the past have primarily focused on residential buildings, but for enhanced community resilience, the same concept can apply to non-residential buildings. This is also covered in Section 4.8.

4.2 FEMA Policies on Habitability

The FEMA Individual Assistance (IA) Grant program[1] addresses the issue of post-disaster habitability of residential buildings. FEMA may provide financial assistance and direct services to eligible individuals and households who have uninsured or underinsured necessary expenses and serious needs through the IA Program. This assistance is not a substitute for insurance and cannot compensate for all losses caused by a disaster; it is intended to meet basic needs and supplement disaster recovery efforts. The FEMA Home Repair Assistance[2] program provides financial assistance to repair damage to an owner-occupied primary residence, utilities, and residential infrastructure, as a result of a Presidentially-declared disaster. The FEMA Home Repair Assistance program is intended to make a damaged home safe, sanitary, or functional[3]. It is not intended to return the home to its pre-disaster condition.

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[1] FEMA *Individual Assistance Program and Policy Guide* (2019): https://www.fema.gov/media-library/assets/documents/177489

[2] https://www.fema.gov/what-specific-items-are-covered-housing-assistance

[3] https://www.fema.gov/news-release/2018/10/08/fact-sheet-safe-sanitary-and-functional-homes

Following inspection, FEMA may make a "Habitability Repairs Required" determination, which may require specific repairs to be made to an applicant's home based on the disaster-caused damage to the structure or supporting systems. When the damage impacts safety, security, or functionality of the home, FEMA may provide assistance for repairs necessary to restore the pre-disaster residence to a habitable condition only, which is not necessarily the complete pre-disaster condition of the residence.

4.3 Habitability Evaluation Approaches and Evaluator Skills

4.3.1 Habitability Evaluation Approaches

Habitability evaluations have been conducted in past incidents, but the approaches are less standardized than those used for building safety evaluations. For example, there is no typical placarding process, like there is with building safety evaluations. Evaluations related to habitability are conducted by a variety of parties, and they depend highly on the type and scale of the incident and the damage that occurs. There has been a greater emphasis in the past on critical environmental hazards like gas leaks, blackwater in floods, or wildfire smoke and evaluations of building services and code deficiencies have been limited.

It is recommended that for buildings that are structurally sound, the post-disaster habitability evaluation include consideration of the following questions:

- What restrictions exist, if any, that could restrict or limit the safe habitability of the building/structure?
- Is the building/structure safe enough to be inhabited?

Past evaluation approaches have included the following:

- First responders, including police and fire personnel, perform initial assessments of buildings, cordon off areas with downed power lines or other hazardous conditions, and get injured people to appropriate medical care. They help identify the locations and severity of damage and provide preliminary information on apparent environmental hazards and building services that may not be functioning.
- Utility personnel investigate and address downed power lines, gas leaks, damaged systems and equipment, and other hazardous conditions.
- Trained personnel from agencies, such as the local health department, assess environmental hazards in the disaster area in general, within severely impacted blocks, and in adjacent streets. The assessment may

be based on visual surveys of the exterior of buildings and limited building access. In general, a unit-by-unit inspection to assess interior conditions is not conducted. Note that the capacity of skilled resources for such an assessment may be limited, as critical duties related to the emergency may still be the primary focus for these professionals.

- Although the focus of post-disaster building safety evaluations is on structural and nonstructural safety issues, safety evaluators observe environmental hazards or critical building service and code issues and can note them on evaluation forms and placards. This is limited to issues that can be readily observed, such as smelling leaking gas, noting an obvious chemical spill, mold growth, or blocked or threatened exit paths.

4.3.2 Evaluator Skills Needed

Evaluations for habitability require different evaluator skills and training than those for building safety. For some environmental hazards, specialists are needed (see Section 4.4).

Habitability evaluations can also require multidisciplinary skills, including the following:

- Technical competence in identifying a wide range of environmental hazards and code deficiencies, and in discerning likely harm to the health and safety of potential occupants. Detailed evaluations may require specialized skills and training, and multiple individuals may be needed.
- Leadership capacity to reach timely go-no-go decisions regarding habitability based on incomplete information about the conditions encountered. Constraints arise because time, budget, and equipment will be limited; additionally, all hazards may not be visible and readily determined given the time period allotted for the evaluation, and thus contingencies must be considered to account for missing data or unknowns.
- Attentiveness to who will be occupying the building or structure—and any vulnerabilities they bring, that would be made worse by the conditions encountered, safeguarding those with disabilities or access and functional needs. This information should be directed to local Voluntary Organizations Active in Disaster (VOAD) or other organizations.
- Ability to convey information regarding management of hazards and risk.

- Ability to sustain the commitment of resources over the short and long term, to recalibrate decisions as conditions change, and to extend essential resources to expedite restoration.
- Familiarity with local laws and regulations that protect health and ensure safety.
- Attentiveness to community engagement and expectations arising from the public review process.
- Knowledge of pre-disaster conditions that impact livability (e.g., contaminated well water, areas built on industrial sites).

4.4 Environmental Hazard Evaluation

Environmental hazards can restrict habitability. A short video overview of key environmental hazards and practical guidance following a disaster is available from the U.S. Department of Housing and Urban Development (HUD).[4]

Although environmental hazards are many, the goal is to return people to healthy housing. HUD defines the following Eight Healthy Homes Principles[5]: (1) Keep it dry; (2) Keep it clean; (3) Keep it safe; (4) Keep it well-ventilated; (5) Keep it pest free; (6) Keep it contaminant-free; (7) Keep your home maintained; and (8) Thermally controlled. A useful primer on typical residential environmental hazards, including asbestos, lead, arsenic, disease vectors and pests, is available from the Centers for Disease Control (CDC and HUD, 2006).

Not every environmental hazard is common in every incident type. Section 4.4.1 through Section 4.4.11 present basic information about environmental hazards and discuss considerations related to building evaluation when such hazards are present. Table 4-1 correlates incident type with common environmental hazards.

In some cases, hazards may impact only a portion of the occupiable space. For example, where only the lowest floor of a multi-story building has been impacted by blackwater, other floors may be able to be occupied. Pipe insulation that is damaged and may contain asbestos, located in a basement that can be sealed off, may not pose a risk to habitability for most of the building.

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[4] *Returning to Your Flood Damage Home*: https://www.youtube.com/watch?v=aY4v6y2mcCo

[5] https://www.hud.gov/program_offices/healthy_homes/healthyhomes

Table 4-1 Common Environmental Hazards by Incident Type

Incident Type	Gas	CO*	Chemical Release	Soot and Fumes	Blackwater, Sewage, and Mold	Asbestos	Lead-Based Paint	Parasites	Wild, Stray, Dead Animals	Insects	Refuse and Debris
Earthquake	×	×	×			×	×	×	×	×	×
Hurricane	×	×	×		×	×	×	×	×	×	×
Tornado	×	×	×			×	×		×		×
Flood	×	×	×		×	×	×	×	×	×	×
Tsunami	×	×	×		×	×	×	×	×	×	×
Land instability	×	×	×			×	×				×
Volcano	×	×	×	×		×	×		×		×
Snow/hail/ice	×	×	×			×	×				×
Fire	×	×	×	×		×	×	×	×	×	×
Explosion	×	×	×	×		×	×				×

* Carbon Monoxide

Best Practice

Limited, initial evaluation of common environmental hazards (a "scan") is included in a Rapid Evaluation, as part of a building safety evaluation conducted in accordance with best practice guidance described in Chapter 3. However, no standardized guidance exists. More involved evaluations will necessarily be performed later, often by specialists. The following sections provide best practice evaluation strategies for building safety evaluators that encounter environmental hazards on site.

Interim Recommendation

Until specific habitability evaluation guidance for environmental hazards is developed, this *Guide* presents evaluation strategies for building safety evaluators trained in accordance with best practice guidance presented in Chapter 3. Also included are a list of triggers for when a building safety evaluator should contact a specialist or owner. A detailed discussion of action items for specialists and owners is not covered in this *Guide*. Incident-specific strategies are discussed in Section 4.4.1 through Section 4.4.11. Table 4-2 provides a summary of evaluation strategies for building safety evaluators, specialists, and owners by environmental hazard type. Key terms, acronyms, and references are defined within the body of each section.

Table 4-2 Environmental Hazard Evaluation Strategies

Report Section	Hazard	Evaluation Strategy for Building Safety Evaluator	Evaluation Strategy for Specialist or Owner	Specialist/Comments
4.4.1	Natural gas	• If evidence of gas leak (smell) or fire is observed: ◦ Evacuate the building. ◦ Avoid using mobile phones and other potential ignition sources nearby. ◦ Notify the fire department or utility.	Investigate, shut off gas where appropriate, and mitigate leaking gas line.	Fire department or utility
4.4.2	Carbon monoxide (CO)	• If there is damaged HVAC equipment in the building, or equipment such as a generator, inside or closer than 20 feet from doors windows, or any other building opening, notify the requesting jurisdiction. • If CO alarm goes off, get to fresh air and notify the fire department or utility.	Use intrinsically safe, hands-free, CO or multi-gas meters.	Fire department or hazard materials unit
4.4.3	Chemical release	• Identify type of facilities in the area that may contain chemicals (chemical storage, industrial plant, laboratory), including NFPA identification sign. • If obvious breached containers, solid or liquid spills are identified: ◦ Notify fire department. ◦ Anyone witnessing an oil spill or chemical release near or in navigable waters should call the Coast Guard's National Response Center hotline at 800-424-8802. ◦ Barricade and post RESTRICTED USE or UNSAFE placard at safe distance.	• Evaluate evidence of chemical release. • Survey for evidence of soil, water, and air contamination—stains, puddles, oily sheen on water, smoke, airborne dust. • Conduct areawide survey.	Fire department or hazard materials unit
4.4.4	Soot and fumes	• If active burning in the area is identified and proximity of building to fire and toxicity of source materials is considered: ◦ Notify fire department. ◦ Barricade and post RESTRICTED USE or UNSAFE placard at safe distance.	• Leave windows and doors closed. Run air conditioner with the fresh-air intake closed and the filter clean to prevent outdoor smoke from getting inside. • Designate "clean room;" choose a room with no fireplace and as few windows and doors as possible, such as a bedroom, operate a portable air cleaner. • Evaluate HVAC system effectiveness in filtering small particles.	Fire department, mechanical engineer, and/or environmental health specialist

Table 4-2 Environmental Hazard Evaluation Strategies (continued)

Report Section	Hazard	Evaluation Strategy for Building Safety Evaluator	Evaluation Strategy for Specialist or Owner	Specialist/Comments
4.4.5	Blackwater, sewage, and mold	• If water rose above the sill plate: ◦ Post a RESTRICTED USE placard until drywall and insulation are removed and the wall is confirmed dry. • If sewer or septic components (e.g., toilets, tanks, plumbing) are observed damaged, suspect presence of blackwater and sewage: ◦ Avoid contact with any contaminated water.	• Conduct a visual mold and moisture evaluation using NIEHS (2013). • If the extent of visible mold less than 10 sf, property owners can refer to EPA (2015), CDC (2005), NYC (2008). • Confirm that saturated porous materials (mattresses, upholstery, drywall) have been removed.	• Cleanup activities should be conducted only by qualified, trained, and properly equipped contractors, such as those with Institute of Inspection Cleaning and Restoration Certification (IICRC). • The District of Columbia and some states, such as Florida, Maryland, Texas, Louisiana, New Hampshire, and New York require licensure or certification for mold assessors and mold remediators.
4.4.6	Asbestos	• Some common examples of asbestos containing materials include gypsum, drywall tape and filler/mud; pipe, furnace and boiler insulation; sprayed-on ceiling finishes; siding; and fireproofing. • If any of these are damaged, flaking, or friable: ◦ Evacuate the building. ◦ Barricade and post a RESTRICTED USE placard.	• Query the jurisdiction for asbestos records (permits) for larger buildings to identify or discount the potential for asbestos-containing materials. • If material containing more than 1% asbestos has been severely damaged, the area should be restricted and asbestos mitigated.	Only accredited asbestos professionals and properly trained and equipped contractors should evaluate and remediate.
4.4.7	Lead-based paint	• If the building was constructed or renovated before 1978, it may contain lead-based paint: ◦ Observe paint for fair or poor condition—deterioration, flaking, dust. ◦ Communicate need to cover/isolate areas of lead dust which may be encountered by children or families. This is only a temporary measure post-disaster.	• Evaluate presence of paint debris, flaking, or chipped paint. • Conduct sampling and lab tests.	Only accredited abatement contractors who are properly trained and equipped should remediate.
4.4.8	Parasites	• If contaminated food, water, and surfaces are observed: ◦ Avoid contact. ◦ Notify public health officials.	• Evaluate presence of standing water, lack of sanitation, and unsanitary conditions that would promote the presence of parasites. • Conduct sampling and lab tests.	Public health officials.

Table 4-2 Environmental Hazard Evaluation Strategies (continued)

Report Section	Hazard	Evaluation Strategy for Building Safety Evaluator	Evaluation Strategy for Specialist or Owner	Specialist/Comments
4.4.9	Wild, stray, and dead animals	• If wild, stray, or dead animals are observed: ◦ Avoid contact. ◦ Notify public health officials.	• NIOSH (2018) provides interim guidelines for preventing injury and illness among workers performing animal rescue and recovery efforts in the response to hurricanes. • CDC (2018) provides guidance for dealing with dead animals.	Only properly trained and equipped personnel should control or remove wild, stray, and dead animals.
4.4.10	Biting and stinging insects	• If biting or stinging insects are observed: ◦ Avoid contact. ◦ Wear light colored clothing ◦ Avoid lifting items off the ground. ◦ Notify public health officials.	NIOSH (2010) fact sheet for protection from stinging insects.	Public health officials.
4.4.11	Debris and refuse	• If debris or refuse are observed: ◦ Avoid contact. ◦ Barricade and post a RESTRICTED USE placard. ◦ Notify public health officials if warranted.	Evaluate impacts of debris and refuge on potential hazards for fire, health, and accessibility.	Public health officials when warranted.

Evaluations by specialists are typically performed as a fee-for-service for the client. The requesting jurisdiction, even with volunteer support, may not have the resources to provide this level of evaluation for all of the damaged buildings impacted by an incident confronting their community. FEMA may be called upon to assist with the provision of multiple types of hazard identification and remediation/rebuilding resources and assistance in these cases.

There are resources available to help individual licensed architects, engineers, and building officials to develop the specialty skills required to gain supplemental credentials in environmental hazard evaluation. Advanced proficiency in environmental health fields may be gained, for example, by pursuing the National Institute of Environmental Health Sciences (NIEHS) training program[6].

Additional Discussion and Needs

Multi-tiered decision frameworks, similar to ATC-20-1 and ATC-45 could be developed to delineate the significance of obvious and hidden individual and combined environmental hazards. This would need to be done in the

[6] *Worker Training Program (WTP) for Disaster Preparedness and Response*: https://tools.niehs.nih.gov/wetp/index.cfm?id=556

context of regional conditions, ecology, and climate differences. Additionally, the health status of the impacted or displaced community, and their collective or individual vulnerabilities to adverse health outcomes based on exposure to environmental hazards, need to be factored in. For example, lingering dioxins/furans in soot from fires, chemicals deposited from receding floodwaters, and diseases spread from stagnant waters are some of the issues in assessing the habitability of buildings following an incident. In the meantime, to avoid misleading the users, a disclaimer could be added to the placards to describe what is not included as part of the evaluation. BC Housing[7] has included a statement to this effect on the post-disaster safety evaluation placards for their jurisdiction.

An initial screening by environmental health and safety specialists might be applied first on a larger scale, with building-specific guidance developed in a later phase. Qualifications of the environmental health and safety specialists must be closely matched to expected conditions. If there is a shortage of skilled personnel, a triage system can be used to assign more experienced personnel to more complex situations. Depending upon the type of incident and its scale, it may be necessary for environmental health and safety specialists to coordinate with the Post-disaster Building Safety Evaluation Strike Team (as described in Section 5.3).

Environmental hazards/risks can be categorized in tiers as follows:

- High Hazard: Hazards that pose imminent danger to the habitability of the building (e.g., active chemical spills, carbon monoxide)
- Moderate Hazard: Hazards that pose potentially serious health and safety risks but can be controlled with rapid repairs or control measures (e.g., water intrusion/damage)
- Low Hazard: Hazards that pose less than serious safety and health risks that can be controlled with interim measures to allow immediate occupancy (e.g., damaged heating, ventilation, air-conditioning (HVAC) systems where occupants can use portable air conditioning units or heaters until full repairs are completed)
- Minimal Hazard: Hazards that pose minimal safety and health risks that are part of everyday life (e.g., mice)

4.4.1 Natural Gas

Natural gas is normally distributed through a network of underground pipes and service lines. If a leak occurs, gas migrates into buildings, including

[7] https://www.bchousing.org/about/post-disaster-building-assessments

those without natural gas service. Gas leaks pose a serious threat of explosion and fire and should be dealt with immediately.

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Gas traveling through transmission pipelines might not be odorized, so building safety evaluators should be aware of gas-leak indicators such as hissing or blowing noises, dirt thrown into the air, fire from underground, water blowing into the air at a pond, creek, or river. If there is the smell of natural gas, the building safety evaluator should leave the building and notify the fire department, utility, or authorized representative immediately. These parties may turn off the natural gas service at the meter. No phones or mobile devices should be used inside the building, and potential ignition sources, such as starting or stopping nearby vehicles, machinery, or anything that may spark should be avoided. If someone in the building is reported missing or trapped, emergency personnel should be contacted from outside the building.

4.4.2 Carbon Monoxide

Carbon monoxide (CO) is an odorless, colorless, and toxic gas that can cause illness and death. The symptoms of low levels of CO are headaches, dizziness, disorientation, nausea, and fatigue.

HVAC distribution systems can leak CO into the building from damaged boilers and furnaces. In addition, if there are generators, heaters, or unvented gas, kerosene, or propane appliances in the building, these may also emit CO. The U.S. Centers for Disease Control and Prevention (CDC, 2017) recommends keeping portable generators outdoors and at least 20 feet from doors, windows, or any other building opening.

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The building safety evaluator should make note of any damaged HVAC equipment, as well as equipment, including temporary generators, that is located closer than 20 feet from doors, windows, or any other building opening, and notify the requesting jurisdiction. If CO monitors are available, these monitors should be equipped with audible alarms to warn evaluators when CO concentrations are too high. If the monitor alarms, the evaluator should get to fresh air, and contact the local fire department or utility for response. Owners and specialists may utilize "intrinsically safe," hands-free CO meters or multi-gas meters that include CO to determine the level of CO concentration. Intrinsically safe design prevents the meter from inadvertently contributing to a fire. There are many commercially-available meters on the market that meet this designation. Multi-gas meters typically include sensors for, in addition to CO, percentage of oxygen, percentage of lower explosive limit, and hydrogen sulfide. *Handheld Multi-Gas Meters Market Survey Report* (DHS, 2016) presents an evaluation of commercially-available multi-gas meters.

4.4.3 Chemical Release

If there has been a chemical release (toxic, corrosive, flammable, reactive, irritant, or ecotoxic), habitability concerns are numerous: burns resulting from skin contact with corrosive chemicals; inhalation of toxic and/or flammable vapors; respiratory tract injury; and poisoning, including from contaminated food or water.

Chemical releases occur as a result of:

- Ruptures of pipework and pipelines
- Displacement of storage tanks
- Damage to chemical drums
- Flooding of soil containing fertilizers, herbicides, and insecticides
- Runoff from flooded waste sites and landfills
- Damage to the power supply that can cause process upsets and derail control mechanisms such as the operation of control valves, and maintenance of safe temperatures and pressures. These failures can lead to runaway chemical reactions and blow-down.

As floodwaters recede, residue chemicals may remain in buildings, embedded in porous materials, such as gypsum wallboard and wood.

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If obvious breach of containers, solid spills, or liquid spills are identified, the building safety evaluator should notify the fire department, barricade, and post RESTRICTED USE or UNSAFE placards at a safe distance. If an oil spill or chemical release occurs near or in navigable waters, the U.S. Coast Guard should be notified[8].

In assessing the potential for chemical release, the site of the building should also be considered. For example, are there facilities that may contain chemicals (as indicated by an NFPA diamond identification sign[9]), such as

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[8] Anyone witnessing an oil spill or chemical release near or in navigable waters should call the U.S. Coast Guard's National Response Center hotline at: 800-424-8802

[9] https://www.nfpa.org/Assets/files/AboutTheCodes/704/NFPA704_HC2012_QCard.pdf

industrial facilities, storage tanks, agricultural land, gasoline stations, in areas that have been flooded? How close is the building to these areas? If there is a known chemical release in the area, consequences in impacted buildings are to be evaluated by the appropriate authority as governed by the jurisdiction. Accordingly, the building safety evaluator should notify the appropriate jurisdiction, such as the fire department, the U.S. Coast Guard, the U.S. Environmental Protection Agency (EPA) or State agency.

Flood waters may bury or move industrial chemicals from their normal storage places. Propane tanks pose the danger of fire or explosion. If any are found, the local police or fire department or Authority Having Jurisdiction (AHJ) should be contacted immediately. Car batteries may still contain an electrical charge and acid may have spilled from them; no contact should be made. Containers of dry chemicals may have become wet and can be dangerous; the local fire department should be notified.

4.4.4 Soot and Fumes

If there is active burning in the area, the toxicity of soot and fumes will depend on what is burning, wind direction and speed, and the concentration and size of the particles. Burning of plastics common in household furnishings produces highly toxic soot, and volcanic eruptions can produce hazardous gases. In addition, individual susceptibility of potential building occupants should be considered—those with pre-existing medical conditions (heart or lung conditions), the elderly, smokers, and children may be most affected.

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For a building in an area of active burning, the building evaluation will necessarily focus on the outdoor air quality and the ability of the building systems to filter the incoming air. If active burning is encountered in areas where reports have not yet been made, then the building safety evaluator should notify the fire department, barricade, and post RESTRICTED USE or UNSAFE placards at a safe distance. A mechanical engineer and/or environmental health specialist may also be helpful in determining the habitability of the building by evaluating the effectiveness of the HVAC system, e.g., for filtering small particles, and measuring the air quality.

For prolonged active burning, the building safety evaluator may encounter buildings with rooms designated as clean rooms by owners or specialists who have implemented recommended measures (e.g., by following EPA guidance[10]). In such a case, the building safety evaluator should post the

[10] https://www.epa.gov/indoor-air-quality-iaq/create-clean-room-protect-indoor-air-quality-during-wildfire

building RESTRICTED USE, except for the clean room, since that area of the building has measures in place to reduce the amount of soot and fumes.

When working under conditions of active burning, it will not be unusual for the building safety evaluator to encounter residents who do not evacuate their buildings to avoid medically dangerous situations. *Wildfire Smoke: A Guide for Public Health Officials* (EPA, 2019) cites a common advisory during a smoke episode, which is to stay indoors, where people can better control their environment. Relief from smoke and heat are best provided when buildings have filtered air and climate control—sometimes these are public cleaner-air shelters for those whose buildings do not have adequate air filtration or cooling equipment. In high heat conditions, the ability to stay cool, hydrated, and inside, can provide needed relief from prolonged smoke episodes. CDC (2019) provides information on protection after a volcanic eruption. The building occupants and building safety evaluators should follow the guidance of local emergency managers and public health officials regarding decisions to shelter-in-place.

4.4.5 Blackwater, Sewage, and Mold

Floodwaters may be contaminated with blackwater containing sewage, bacteria, viruses, and parasites. Blackwater cannot be reliably identified visually, and only microbial testing confirms its presence. The insurance industry references the Institute of Inspection Cleaning and Restoration Certification (IICRC)[11] S500, which defines contaminated water very broadly and considers all water originating from sea water, ground or surface water, rising rivers and streams, and wind-driven rain from hurricanes and tropical storms to be grossly contaminated water (Category 3), requiring specially qualified, trained, and equipped contractors to remediate.

In buildings damaged by floodwaters, bacteria are the first to proliferate particularly below the waterline in drywall. Bacteria foul surfaces and damage building materials. Over 100 viruses can be found in sewage which can cause harm to both evaluators and occupants.

Mold poses a health risk after floods; floodwater wicks up drywall by capillary action, stimulating mold growth. If the building was flooded and not dried out within 24-48 hours, mold proliferation is likely. Time spent in these conditions should be limited.

Mold exposure can result in worsening asthma symptoms and allergic reactions. Persistent mold and dampness can result in coughing, wheezing,

[11] https://www.iicrc.org/page/SANSIIICRCS500

upper respiratory symptoms, shortness of breath, respiratory infections, bronchitis, allergic rhinitis, and eczema. Substantial water damage may result in proliferation of *Stachybotrys* and *Memnoniella*, which include target organisms associated with potentially serious health problems.

Persistent dampness inside walls, crawlspaces, attics or HVAC chases can support mold growth, which might only be noticeable by musty odors.

Figure 4-2 Look for mold growth above the floodwater level (FEMA, 2006).

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Observation of water lines left from the flood event will often be sufficient as evidence of floodwater. The CDC recommends protective gear when entering a mold-damaged building[12]. If mold is suspected, the building safety evaluator should perform an exterior evaluation only.

If the water is contaminated with sewage (e.g., evidence of damage to sewer or septic components), or with chemical or biological pollutants, suspect presence of blackwater. Avoid all contact with contaminated water.

Standard protocol in building safety evaluations is to give the building a RESTRICTED USE placard if there is evidence that water levels rose above the sill plate. The California Governor's Office of Emergency Services (Cal OES) Safety Assessment Program (SAP) *Evaluator Training Manual* (Cal OES, 2016a) presents an example building (Building 4) that was flooded and has mold. The text states that the structure should be tagged "RESTRICTED USE" and that it would be acceptable for entry for "possession retrieval only if personal protection against mold is worn." Once the mold is remediated, there would be no need to wear personal protection. Another reason to use the

[12] https://www.cdc.gov/mold/What-to-Wear.html

RESTRICTED USE placard in this situation is that, in most cases, electrical lines and outlet boxes will have been submerged and may need review and remedial work by a qualified electrician.

FEMA 549 (FEMA, 2006) outlines steps for assessing a building for dampness and the associated damage from bacteria/mold, such as confirming that the building is dry, saturated porous materials (e.g., mattresses, upholstery, drywall) have been removed, and other materials are covered with plastic drop cloths or fabric painter cloths for protection.

EPA (2015), CDC (2005), and the City of New York (NYC, 2008) provide guidelines for homeowners to evaluate habitability of parts of a residence impacted by mold caused by clean water for a small, manageable area of mold growth. An area impacted by mold is considered small and manageable (therefore possibly the area can be considered temporarily habitable) as follows:

- By observation of dryness or limited amount of mold (less than 10 square feet).
- Moisture mapping by taking moisture measurements with a moisture meter over a large surface, a wall, for example (to compare readings to control areas and finding minimal difference).

4.4.6 Asbestos

Although many uses of asbestos are technically allowed today, several uses of asbestos were banned in the 1970s. If a building was constructed or renovated before 1978, it is more likely to contain asbestos, which would be hazardous if it is pulverized or otherwise reduced to fibrous dust (friable) and is breathed. Even though medical symptoms may not appear for years or decades, exposure to asbestos can increase risk of lung cancer, asbestosis, and mesothelioma. If a component contains more than 1% asbestos, it is considered asbestos containing material (ACM), and removal requires certified, trained personnel using procedures detailed in applicable regulations, for worker and occupant protection. ACM is only hazardous if disturbed. The following are a few examples of materials that may release asbestos when damaged:

- Gypsum, drywall tape, and filler/mud
- Pipe, furnace, or boiler insulation
- Sprayed-on ceiling finishes
- Siding and fireproofing

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During the Rapid Evaluation of the building, the building safety evaluator should take note of the severity of the condition of the asbestos (popcorn ceiling, broken pipe insulation, or damaged drywall in a pre-1970 building) with regards to habitability. If the condition is severe, the evaluator should vacate at once, and post a placard communicating that building entry is only permitted with appropriate personal protective equipment (thereby a RESTRICTED USE placard), if no other issues are present. If severe damage to ACM is suspected, it must be evaluated by a qualified professional. No one should attempt to handle ACM unless fully certified, licensed, and equipped to do so.

There could be a large-scale release of asbestos into the air if there are a large number of collapsed buildings in a major incident such as an earthquake, or even if one large building collapses. In this case, many buildings could quickly be determined to require restricted access.

It is recommended that as part of pre-disaster planning, jurisdictions develop an inventory of older buildings that have not undertaken substantial alterations and/or more specifically asbestos removal. During post-disaster building evaluation, the Post-disaster Building Safety Evaluation Strike Team Leader, as defined in Section 5.3 of this *Guide*, can query the jurisdiction for asbestos records (permits) for larger buildings to identify or discount the potential for asbestos-containing materials and the likelihood of a potential health risk post-disaster. Then, depending on the incident type, certain assumptions can be made as to whether or not the potentially contaminated materials were jostled, made wet, or otherwise disturbed during the disaster.

4.4.7 Lead-Based Paint

If the building was constructed before 1978, it may contain lead-based paint. Areas in buildings constructed before 1978 with paint debris, flaking or chipping paint should be isolated, e.g., covered with plastic sheeting, as a temporary control measure. Note that areas around the building may contain lead dust from chipping or flaking exterior paint.

Lead poisoning can result from hand-to-mouth transfer of lead-contaminated dust from peeling paint or soil, and can cause learning disabilities in children, and problems with high blood pressure, fertility, digestion, joint pains, and memory loss.

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If paint debris, flaking or chipping paint is present, and likely to be encountered by children or families returning to the building, the evaluator should communicate the need to wet clean/cover/isolate these locations, e.g., by covering with plastic sheeting, as a temporary control measure.

For evaluation of lead-based paint hazards in child-occupied buildings, training in lead risk evaluation is recommended and required by most jurisdictions. No one should attempt to handle lead dust unless fully certified, licensed, and equipped to do so.

The requesting jurisdiction may offer assistance or may require the building owner to complete a lead paint evaluation and enlist qualified professionals to undertake repairs.

4.4.8 Parasites

A parasite lives on or in a host organism and gets its food from its host.[13]

Three main classes of parasites can cause disease in humans, and can be encountered as a result of contact with contaminated floodwaters or food, or direct contact:

- Protozoa: transmitted through contaminated food or water resulting in diarrhea (e.g., from *Cryptosporidium* and *Giardia*).
- Helminths (worms): found in unsanitary conditions or unsafe water, include roundworms and tapeworms, which may cause nausea, wasting, and weakness.
- Ectoparasites: ticks, fleas, lice, and mites attach or burrow into the skin and remain there causing skin lesions and allergic response.

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For a building evaluation, the issue of parasites is one of evaluating the presence of standing water, lack of sanitation, and unsanitary conditions that would promote the presence of parasites. Involvement of medical/public health professionals would be appropriate for addressing resolution of the medical issues associated with these conditions. Typically, this is an area-wide issue, and not as relevant to building-by-building evaluations.

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[13] https://www.cdc.gov/parasites/about.html

4.4.9 Wild, Stray, and Dead Animals

Animal bites and scratches, rabies, and other diseases transmitted from animals, and exposure to allergens (dander, fur, scales, saliva and wastes) can cause injury, illness, and respiratory and skin disorders.

Best Practice Evaluation Strategy for Building Safety Evaluator

Displaced animals should be avoided by building safety evaluators. Only public health specialists who have received proper training in animal restraint, handling, and care, and who are properly equipped, should come in contact with wild, stray, and dead animals.

The National Institute for Occupational Safety and Health (NIOSH) has issued interim guidelines (2018) for preventing injury and illness among workers performing animal rescue and recovery efforts in the response to hurricanes.

A building evaluator should not come in contact these carcasses. CDC (2018) provides guidance to specialists for dealing with dead animals.

4.4.10 Biting and Stinging Insects

Bees, wasps, hornets, fire ants, and scorpions all have the potential to injure building evaluators, as well as impact the habitability of a building.

West Nile virus is a mosquito-borne disease. An infected mosquito transmits the virus to human hosts by biting them. While some infected people may not develop symptoms, in other cases symptoms may include high fever, headache, neck stiffness, disorientation, muscle weakness, and paralysis. Mosquito prevalence is highly dependent on rain and standing water for mosquito breeding sites and appropriate temperatures for survivability. Other mosquito-borne diseases include dengue, Zika, and St. Louis encephalitis.

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The building safety evaluator should avoid all contact with biting and stinging insects. Building safety evaluators with a history of severe allergic reactions to insect bites or stings should carry an epinephrine autoinjector and wear medical identification jewelry stating their allergy. Evaluators should avoid lifting items off the ground, as they may be covered in biting or stinging insects; also bushes, tall grass and leaf litter should be avoided. Light-colored clothing, e.g., long-sleeved shirts, long pants tucked into socks, and hat, will facilitate spotting any biting or stinging insects.

NIOSH (2010) has issued best practice guidance for protection from stinging insects.

4.4.11 Debris and Refuse

Debris includes demolished buildings (broken glass, nails, screws, and other sharp objects that present puncture or impalement hazards; and bulky, often water-damaged, contaminated, moldy waste such as gypsum drywall, lumber, carpet, furniture), garbage (discarded food, containers), vegetative matter (trees, leaves, plants), hazardous waste (oil, batteries, pesticides, paint, cleaning supplies), and large appliances (refrigerators, washers, dryers, stoves, dishwashers). The hazards associated with these materials include chemical exposure, unsanitary conditions, contact with disease-carrying vectors, such as rodents, fires/explosions, blocked access, unstable surfaces, narrow, confining, restrictive spots, and overhead hazards (leading to head injuries). Debris moved to the curb during clean-up activities may limit access to the building from the street by evaluators.

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In a building evaluation, debris and refuge impacts on habitability are evaluated to include potential hazards for fire, health (as a result of decomposing debris), and accessibility.

The building safety evaluator should avoid contact, and, if the debris and refuse impact the habitability of the structure, barricade and post a RESTRICTED USE placard and notify public health officials if warranted.

4.5 Building Systems and Services: Permanent Standards and Potential Temporary Standards

A functional building includes mechanical, electrical, plumbing, fire alarm, and fire sprinkler systems. If these systems are damaged by an incident (see examples in sidebar), the question for habitability evaluation is whether the loss of function of one or more building system should prevent or restrict reoccupancy, or whether there are temporary standards that can be employed during recovery to allow for continued occupancy post-disaster interim use of buildings.

Temporary post-event occupancy standards may be quite basic when compared with the level of services and functionality the U.S. population has come to expect. The AHJ must weigh the risk of continued occupation of a structure with temporary standards with the benefit of the shelter it will provide to the residents. Risk will vary by the size and type of structure; reoccupancy of a single-family dwelling likely poses a much lower risk to its

Examples of Incident Impacts on Building Systems and Services

Hailstones can damage HVAC equipment regulating indoor air temperatures.

Ash from a volcanic eruption or wildfire can corrode HVAC or electrical grid equipment.

Earthquake ground shaking can topple HVAC equipment or emergency generators.

Ice storms can damage power lines.

occupants (low number of occupants, easy to exit) than reoccupancy of a high-rise apartment building (many occupants, more difficult to exit in a secondary incident (e.g., fire)).

The following sections discuss different building systems and the various codes and standards that typically apply to each of them under ordinary circumstances (pre-disaster). These criteria are presented as a way to denote the habitability baseline that exists in most communities. This baseline can then be compared to potential temporary standards. Table 4-3 summarizes key systems, permanent (baseline) standards, and some potential temporary standards. Key terms, acronyms, and references are defined within the body of each section.

Table 4-3 Permanent Standards and Potential Temporary Standards for Building Systems and Services

Report Section	System/ Service	Permanent Standards	Potential Temporary Standards/Issues
4.5.1	Sanitation	• IRC, IBC, or NFPA 5000. • Every dwelling unit must have a toilet, lavatory, and a tub or shower.	Community restroom and shower facilities.
4.5.1	Lighting, ventilation, heating and cooling	• IRC, IBC, NFPA 5000, and ASHRAE 55. • Glazing at least 8% of floor area, with half openable. • Heat to 68 F.	• Reduced ventilation and light. • Temporary heating alternatives will likely depend on climate. Use of wood-fired appliances (wood stoves and fireplaces) or temporary fuel-fired (kerosene) appliances may be allowed. Extreme caution is advised in these options as there is an increased risk of CO poisoning and the CO detectors in the dwelling may not be operational. • Allow the use of natural ventilation (operable windows). In areas where extreme heat may create untenable conditions that cannot be alleviated by natural ventilation it may be not be possible to allow in situ occupancy to continue in order to ensure the safety of the inhabitants. • Increased ventilation if cooling is essential.
4.5.1	Electricity	• NFPA 70, *National Electrical Code*. • Minimum number of receptacles/fixtures.	• Reduction in number of receptables and fixture. • Receptacles are not required to be energized if there is no power. • Temporary power can be provided by permanently installed back-up generators, temporary generators or existing on-site renewable systems (e.g., solar/photo-voltaic, wind), or battery systems.
4.5.1	Potable water	• IRC, UPC. • Every dwelling must have potable water supplied to plumbing fixtures and plumbing appliances.	• Bottled water, community distribution centers (water trucks, temporary water tanks). • Graywater (bath water) may be captured on-site for use to flush toilets.

Table 4-3 Permanent Standards and Potential Temporary Standards for Building Systems and Services (continued)

Report Section	System/ Service	Permanent Standards	Potential Temporary Standards/Issues
4.5.2	Fire and CO alarms and fire protection systems	• IRC, IBC, IEBC and NFPA 5000. • Varies by dwelling type but may include: ◦ Smoke detectors, CO detectors, heat detectors ◦ Fire extinguishers ◦ Emergency exit lighting ◦ Emergency communications system ◦ Automatic fire suppression system ◦ Standpipe, fire pump, access to the fire department connection ◦ Smoke control system (high-rises, atriums)	• Initially, fire watch, additional extinguishers, and battery-powered smoke and CO alarms. • Then restoration of electrical alarms and emergency exit illumination. • Then sprinklers, standpipes, fire pumps, and other specialized systems (e.g. smoke control).

4.5.1 *Mechanical, Electrical, and Plumbing Services*

4.5.1.1 Pre-disaster Building Code Requirements

Model codes establish minimum standards for habitability. The codes used in the United States for new construction include the International Code Council's (ICC) family of interrelated codes, especially the *International Residential Code* (IRC) and the *International Building Code* (IBC), and the National Fire Protection Association's NFPA 5000, *Building Construction and Safety Code*, and NFPA 101, *Life Safety Code*. Both the ICC and NFPA reference NFPA 70, *National Electrical Code* (NEC).

Existing structures may be regulated by the *International Existing Building Code* (IEBC) for renovations, repairs, and remodeling or by the *International Property Maintenance Code* (IPMC). Both codes recognize that existing structures may not be able to comply with all the requirements for new construction. Chapter 11 of the IEBC offers performance method guidance for a "controlled departure from full compliance with technical codes." While the IEBC and IPMC suggest a reduced level of compliance, they are viewed as providing a safe and acceptable level of habitability. Following an incident, it is anticipated that neither full compliance with the requirements for new construction nor a reduced compliance level as defined in the IEBC or IPMC will be possible for some buildings to achieve. This then necessitates consideration of a temporary reduction in habitability standards so as to allow for people to shelter within their homes.

The IPMC defines a structure that is unfit for human occupancy (habitation) in broad terms that leave a certain amount of discretion to the AHJ, as follows:

[A] 108.1.3 Structure unfit for human occupancy. A structure is unfit for human occupancy whenever the code official finds that such structure is unsafe, unlawful or, because of the degree to which the structure is in disrepair or lacks maintenance, is insanitary, vermin or rat infested, contains filth and contamination, or lacks ventilation, illumination, sanitary or heating facilities or other essential equipment required by this code, or because the location of the structure constitutes a hazard to the occupants of the structure or to the public.

The IPMC provides for placarding of structures in Section [A] 109.1, as follows, "when, in the opinion of the code official, … there is actual or potential danger to the building occupants or those in the proximity of any structure because of explosives, explosive fumes or vapors or the presence of toxic fumes, gases or materials, or *operation of defective or dangerous equipment*… The code official shall cause to be posted at each entrance to such structure a notice reading as follows: 'This Structure Is Unsafe and Its Occupancy Has Been Prohibited by the Code Official.'" For more information related to the authority of code officials to inspect and placard damaged buildings see Section 2.5 of this *Guide*.

The following are examples of the types of minimum standards established by the model building code organizations for habitable spaces. The examples cited below are for residences, such as one- and two-family dwellings, attached townhomes, as defined by the IRC. Requirements for larger structures, such as apartments, dormitories, or hotels, will be different as they require a higher level of safety. The IRC and NFPA codes contain provisions for sanitation, light, ventilation, and electrical power such as:

- Sanitation
  - The IRC states that every dwelling unit must have a water closet (toilet), lavatory, and a tub or shower. The occupancy definition of one- and two-family dwellings in NFPA 5000 also requires bathroom facilities.
- Lighting, Ventilation, Heating, and Cooling
  - Light and ventilation for buildings are required in both codes. The required glazing is in the amount of at least 8 percent of the floor area with half of that (4 percent) openable. If natural light is not provided, both codes require a minimum level of switched receptacles for electrical lighting.
  - Conditioned space (heated) is also required. The IRC requires heating to not less than 68 F, and NFPA 5000 has a similar provision through a reference to ASHRAE 55, *Thermal Environmental*

Conditions for Human Occupancy. Neither code requires habitable spaces to be cooled to a certain temperature.

- Electricity
  - Electrical systems are governed by NFPA *70 National Electrical Code*. Every habitable room is required to have receptacles and certain rooms (kitchen, bath, laundry) are also required to have light fixtures.
- Plumbing (Potable Water)
  - The IRC states that potable water is required to be supplied to plumbing fixtures and appliances, "except where rain water, treated gray water or reclaimed municipal water is supplied to water closets, urinals and trap primers." NFPA 5000 references the *Uniform Plumbing Code* (UPC) which requires hot and cold water "except where not deemed necessary for safety or sanitation by the Authority Having Jurisdiction."

Other entities also establish habitability standards, their definitions and minimum requirements may not align with those of the model code organizations:

- Minimum Property Requirements published in the *FHA Single-Family Housing Policy Handbook* (HUD, 2019) apply to homes purchased utilizing Federal Housing Administration (FHA) insured mortgages. They were established to ensure a minimum level of safety and as a protection for the borrower and to ensure the borrower has "a fundamentally sound place to live."
- The U.S. Department of Housing and Urban Development (HUD) established a *Housing Habitability Standards Inspection Checklist*[14] for use after in New York after Superstorm Sandy. HUD notes that "The habitability standards are different from Housing Quality Standards (HQS) used for other HUD programs. Because HQS criteria are more stringent than habitability standards, a grantee could use either standard."
- Local health departments can establish minimum housing requirements as well. An example is the Health & Hospital Corporation (HHC) of Marion County, Indiana. The HHC Board has the legal authority to make and adopt appropriate ordinances. *Code of the Health & Hospital Corporation of Marion County* (Marion County, undated) Chapter 10, Minimum Standards for Residential Property and Housing, establishes minimum standards for plumbing, HVAC, electrical service, light, and ventilation.

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[14] https://www.hud.gov/sites/documents/DHAPSANDYHABITCHKLIST.PDF

- Municipal governments can adopt their own version of a housing code with minimum habitability requirements. Examples include *Housing Maintenance Code*[15] of New York City, New York; *Subtitle II – Housing Code*[16] of City of Seattle, Washington; *Code of Ordinances*[17] of City of Milwaukee, Wisconsin; and *Official City of Los Angeles Municipal Code* and *Existing Building Code*[18] of City of Los Angeles. Housing codes can have unique characteristics that have evolved to address local concerns, such as unreinforced masonry (URM) buildings in Los Angeles or tenements in New York City.

It is often impossible for structures and building systems damaged in a disaster to meet the above noted minimum standards. Therefore, in order to allow residents to continue to occupy their homes, run their business, and re-establish their communities, it will be necessary to develop temporary standards, programs, and processes that could be utilized following a disaster and for a limited time during the recovery process.

For example, after Hurricane Michael in 2018, Bay County Florida sent out a request through the Building Officials Association of Florida (BOAF) for electrical inspectors to deploy them to impacted areas to assist with recovery efforts. BOAF worked with the Florida Department of Emergency Management to coordinate assistance for the areas affected by Hurricane Michael. By prioritizing temporary or partial electrical system restoration, damaged structures were able to be re-occupied (BOAF, 2018).

4.5.1.2 Potential Temporary Standards after a Disaster

Safe Enough to Stay (SPUR, 2012) proposes a temporary habitability standard that would allow occupancy without water, sanitary sewer, and power for up to 30 days after an incident; and after 30 days, these services would need to be restored in order to continue occupancy.

Use of dedicated professionals (e.g., electrical inspectors, HVAC inspectors, and plumbing inspectors) to conduct rapid evaluations can aid in the restoration of essential services when the damage is at the building level (assumes community level infrastructure is intact). Figure 4-3 shows an excerpt from City of Seattle's requirements for connecting temporary overhead service (Seattle, 2019b).

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15 https://www1.nyc.gov/assets/buildings/pdf/HousingMaintenanceCode.pdf
16 https://library.municode.com/wa/seattle/codes/municipal_code?nodeId=TIT22BUCOCO_SUBTITLE_IIHOCO
17 https://city.milwaukee.gov/cityclerk/ordinances#.XdxnMOhKhhE
18 https://hcidla.lacity.org/Property-Standards

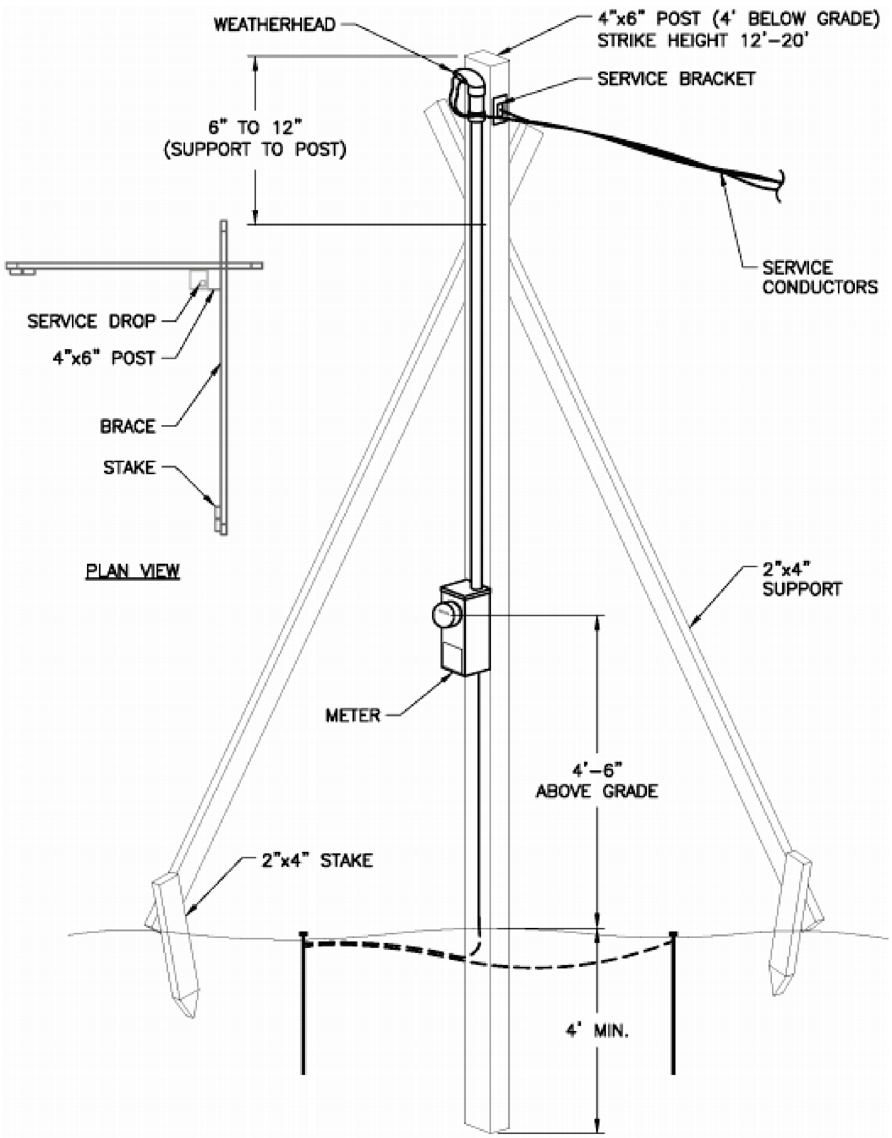

Figure 4-3 Typical overhead temporary service pole from Seattle (2019b) Figure 2.7.

Interim Recommendation

Currently no guidance is available for post-disaster habitability evaluation standards with regards to mechanical, electrical, and plumbing components servicing buildings. The IPMC may offer guidance on minimal acceptable levels. The IPMC is "intended to establish minimum maintenance standards for basic equipment, light, ventilation, heating, sanitation and fire safety." The IPMC provides for "the regulation and safe use of existing structures in the interest of the social and economic welfare of the community."

The IPMC defines a dangerous structure or premises, among other things as:

> *Any portion of a building, structure or appurtenance that has been damaged by fire, earthquake, wind, flood, deterioration, neglect, abandonment,*

vandalism or by any other cause to such an extent that it is likely to partially or completely collapse, or to become detached or dislodged.

The U.S. Senate Committee on Appropriations in Senate Report 114-239 for FY 2017 mandated that the National Institute of Standards and Technology (NIST) develop a report on the development and implementation of an Immediate Occupancy (IO) performance objective. The NIST Special Publication 1224, *Research Needs to Support Immediate Occupancy Building Performance Objective Following Natural Hazard Events*, (NIST, 2018) identifies the basic and applied research and implementation activities, as well as supporting engineering principles, needed to improve the performance of residential and commercial buildings to meet an IO performance objective following natural hazard incidents.

The report notes that, in developing criteria for a new IO performance objective, “multiple functional levels that may differ in terms of the acceptable recovery time should be considered, depending on the building’s role in the community, the services it provides, and the hazard level.”

Functional levels may vary from continuous function to partial loss of function for a specified recovery time. The report states that, “building functionality needs to be measured as a function of damage to the building’s structural components, nonstructural components, and any other components or equipment that can hinder functionality. As a result, the quantification of damage, both at the component and system levels, is essential to develop the design criteria to meet IO functionality goals.”

Reduced (below IPMC level) standards for mechanical, electrical and plumbing components allowing interim use of buildings should be developed and vetted. The potential temporary standard should consider the incident and damage type. For instance, in a tornado, the underground utilities are typically not affected, so the potable water supply and the wastewater portion of plumbing system will be unaffected. In a flood, the local sanitary sewers and wastewater treatment facilities may inundated, and so, even if there is no physical damage to the plumbing at an impacted structure, the plumbing sanitary system may have to be taken off-line.

Weather is also a critical factor for HVAC systems. Ice storms that damage local power grids can also impair heating systems and render buildings uninhabitable. Thunderstorms may cause eletrical outages that disrupt the functioning of basement sump pumps leading to storm water back-up issues with equipment (e.g., furnaces and water heaters), electrical panel access, and mold.

The research contemplated by the NIST (2018) study will better inform how partial, temporary functional damage to building systems will impact habitability, especially when the structural system has not been impacted. It is recommended that the NIST effort be monitored so that further research and guidance developed as part of this initiative can assist in advising communities on the impact of the functionality of nonstructural systems.

In addition, dedicated professionals (e.g., electrical inspectors, HVAC inspectors, and plumbing inspectors) should be engaged to conduct assessments in order to aid in the restoration of essential services when the damage is at the building level (assuming community level infrastructure is intact).

4.5.2 Fire Alarm, Carbon Monoxide Alarm, and Fire Protection Services

4.5.2.1 Pre-disaster Building Code Requirements

Fire-related code requirements are contained within the ICC codes as well as NFPA 5000 and NFPA 101. Both the ICC and NFPA reference the NEC. The current code requirements are as follows:

- Smoke Alarms
  - NFPA 5000 and the ICC codes require smoke alarms to be provided within dwellings (single and multi-family). The location requirements for smoke alarms are specific. There are exceptions within NFPA 72, the *National Fire Alarm and Signaling Code*, that are intended to address small dwellings. Specific requirements for multi-family dwelling mandate that systems have both audible and visible notification devices.
- Carbon Monoxide Alarms
  - NFPA 5000 and the ICC codes also require carbon monoxide detectors where fuel fired equipment is installed or attached garages are present.
- Fire Suppression Systems
  - While fire suppression systems (sprinklers) are required by the IRC in new dwellings, the vast majority of states have opted to remove this provision from their adopted code provisions. Sprinklers are required in new multi-family, hotel, high-rise, and many commercial structures.

4.5.2.2 Potential Temporary Standards after a Disaster

The temporary habitability standard proposed by SPUR (2012) recommends that:

- By the end of the first week after the incident, smoke detectors and carbon monoxide detectors be operational in the dwelling. The detector units are allowed to be battery-powered. (Note: Hard-wired units lose functionality during power outages and must rely on batteries.)
- By 30 days following restoration of electrical service, fire alarm systems, other required alarms, and emergency exit illumination must work.
- By 90 days following restoration of water service, automatic fire sprinklers, sprinkler wet standpipes and fire pumps must be operational.

NFPA 101 contains a provision for when a fire alarm system and/or a water-based fire protection system such as a sprinkler system becomes impaired (out of service). Standard practice is to establish a fire watch, which requires monitoring the building to look for evidence of smoke, fire, or any abnormal conditions and alerting the occupants. Although this is standard procedure for commercial construction, it may be an action that could be considered for a multi-family structure, a row of attached single-family homes (e.g., townhomes, brownstones), or for a subdivision or a neighborhood of closely-spaced houses.

Interim Recommendation

Temporary fire safety standards for immediate occupancy should be developed and vetted. Standards should address fire detection as well as suppression.

The Community Emergency Response Team (CERT)[19] program trains volunteers in fire suppression as part of their basic disaster response skills. The training covers fire chemistry, hazardous materials, fire hazards and fire suppression strategies. The thrust of the training is the safe use of fire extinguishers, controlling utilities and extinguishing small fires. This program could be utilized to help address post-disaster fire safety concerns.

The NFPA Firewise Communities[20] program trains residents on how to identify and mitigate potential fire hazards to structures. Programs such as these can provide information and knowledge that can become basis for the development of temporary fire standards.

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[19] https://www.ready.gov/community-emergency-response-team
[20] https://www.nfpa.org/Public-Education/Fire-causes-and-risks/Wildfire/Firewise-USA

As mentioned in Section 4.5.1, research contemplated by the NIST (2018) study will better inform how partial, temporary functional damage will impact habitability. It is recommended that this effort be monitored so that its findings can assist in advising communities on the impact of the functionality of nonstructural systems.

4.6 Other Code Issues: Permanent and Potential Temporary Standards

There are building code compliance issues not directly related to building systems and services that can arise with damage from incidents and impact the ability to reoccupy (inhabit) the building. These include the amount of space available for occupants, means of egress or escape, security, and requirements for persons with access and functional needs. Table 4-4 summarizes key issues, permanent standards, and potential temporary standards.

Table 4-4 Other Code Issues: Permanent and Potential Temporary Standards

Report Section	Issue	Permanent Standards	Potential Temporary Standards/Issues
4.6.1	Habitable space	• IBC and IRC (70 sf), NFPA 5000 (49 sf). • 7 feet high over at least half the room. Local standards may be more stringent.	Reduction in required square footage.
4.6.2	Means of egress / escape	• IRC and NFPA 5000. • Primary and secondary means of egress (unless primary leads directly outside and there are sprinklers), emergency escape in sleeping rooms, side-hinged primary door (no sliding front door), minimum egress widths. • Stair or fire escape for stories above/below grade. • IBC requirements vary*.	• One usable exit from every occupied area. • This should change with building size and will also be affected by the height above grade.
4.6.3	Accessibility for Persons with Disabilities or Access and Functional Needs and Seniors.	• IBC Chapter 11 • State Law (varies by jurisdiction) • 2010 ADA Standards for Accessible Design • 2004 ADAAG Guidelines • Title II of ADA • Title III of ADA Above standards cover: Accessible entrance, path, common /public use areas, doors, switches /outlets /thermostats, kitchens /bathrooms.	• Access on a case-by-case basis. • Depends initially on needs of occupants. • Not a requirement for single-family homes, unless needed by the occupants.
4.6.4	Security	The IRC does not require that doors or windows have locks, but if they do the locks must be readily openable from inside without the use of a key or special knowledge or effort.	• Increased police/security patrols. • Boarding up damage openings. • Is a lockable door needed?

* Code requirements for residential occupancies not allowed to be constructed under the IRC, such as apartments, dormitories, hotels, half-way homes, or boarding facilities, are contained in the IBC. The IBC has specific occupancy type requirements too extensive to list here.

4.6.1 Habitable Space

4.6.1.1 Pre-disaster Building Code Requirements

Minimum standards for habitability are contained within the ICC codes, NFPA 5000 and NFPA 101. As noted in Chapter 1, while this *Guide* explores habitability as a concept that applies to both residential and commercial occupancies, the discussions in this section are limited to the definition of habitability, as defined in the building codes, limiting its application to residences.

Habitable spaces are defined per the IRC as: "a space in a building for living, sleeping, eating or cooking." Not all rooms within a residence are considered habitable. Bathrooms, toilet rooms, closets, halls, storage or utility spaces, and similar areas are not considered habitable spaces. Hotels, apartment buildings, and dormitories will have habitable spaces. Commercial spaces, such as offices, restaurants, and factories, contain occupiable spaces but not habitable rooms. The following are the code requirements:

- Requirements for minimum room sizes and dimensions are established in both the ICC and NFPA codes. These include minimum sizes for habitable rooms, minimum horizontal dimensions in rooms, and other dimensional requirements. These codes do not require a dwelling to have multiple rooms.
- NFPA 5000 and the IRC set a minimum horizontal dimension of 7 feet for habitable rooms. The IRC provision is for one dimension, but for NFPA 5000 this applies to any dimension, which ultimately sets a minimum room size of 49 square feet. The IRC establishes that habitable rooms have a minimum area of 70 square feet.
- Bathrooms are not habitable rooms but have required dimensions. Codes require a clearance of 15 inches from the center of a toilet to any obstruction. They also require 24 inches in front of a toilet. Showers are required to be a minimum of 30 inches by 30 inches.
- The IRC contains an appendix to provide the AHJ with the option to regulate the construction of "Tiny Houses" with provisions for room sizes and heights reduced from those for standard dwellings.

Local health departments have the legal authority to make and adopt appropriate ordinances. As an example, *Code of the Health & Hospital Corporation of Marion County* (Marion County, undated) sets the following Minimum Standards for Residential Property and Housing:

(a) At least one hundred fifty square feet of space shall be provided for the first occupant. An additional one hundred square feet of space shall be provided for each additional occupant.

(b) A room to be used for sleeping shall have at least seventy square feet of space for the first occupant. An additional fifty square feet of space shall be provided for sleeping area for each additional occupant.

The ceiling height of habitable rooms must be at least seven feet; however, any habitable room under a sloping ceiling must have a ceiling height of at least seven feet in at least one half of the floor area. Floor space is calculated in habitable rooms in which ceiling height is more than five feet.

4.6.1.2 Potential Temporary Standards after a Disaster

No potential temporary standards were identified.

Standards for room size and occupant numbers for temporary in-home sheltering should be developed and vetted. Although it is unlikely that a dwelling deemed safe to occupy would be significantly reduced in size from its original dimension, with the advent of tiny houses and micro-apartments, unaffected rooms may be limited in some instances.

The *Sphere Handbook* (Sphere, 2018) is an international standard that provides key actions, key indicators, and guidance notes for planning, location and settlement planning, living space, household items, technical assistance, security of tenure, and environmental sustainability. The *Sphere Handbook* has a minimal amount of definitive guidance, instead indicating that "each affected household has adequate living space to perform basic domestic activities," or that living spaces accommodate "the diverse needs of members of the household for sleeping, food preparation and eating, respecting local culture and lifestyles," and are provided with "optimal lighting conditions, ventilation and thermal comfort."

4.6.2 Means of Egress/Emergency Escape

Building codes only require one entry/exit door for single-family homes. Residential structures also require a secondary means of exiting from sleeping rooms, which is commonly provided via an escape window (doors to the exterior are also acceptable); this is known as a means of escape or the "emergency escape and rescue opening" (IBC *Chapter 10, Section 1030*).

Commercial structures greater than two stories or with occupancy rates greater than 50 persons require two or more exits depending on the number of people allowed in the room, on the floor level, or within the structure. The

IBC defines a "means of egress" as a continuous and unobstructed path of vertical and horizontal egress travel from any occupied portion of a building or structure to a public way. This path, from any room, all the way out of the building, is typically required to have a fire-resistance rating and as such often consists of enclosed hallways or passageways, ramps, and stair towers. These building elements, such as hallways, stairs, just like structural elements (bearing walls, columns, and beams), may be damaged, blocked, or have their rating compromised in an incident.

4.6.2.1 Pre-Disaster Building Code Requirements

The IBC provides extensive information on the design and configuration of those building elements that provide a safe and protected path by which to exit a building. Requirements for residential occupancies vary depending on type, height above grade, and presence of an automatic fire suppression system. In some instances (e.g., apartment buildings), emergency escape and rescue openings are required (see Section 4.6.3 for issues related to accessible design codes and standards).

NFPA 5000 and the IRC require providing a primary means of egress and a secondary means of escape. NFPA 5000 requires sleeping rooms and living areas to have primary and secondary means of escape for dwellings. NFPA 5000 does not require a secondary means of escape when the room has a door leading directly to the outside finished ground level or if fire sprinklers are provided. The IRC requires an emergency escape and rescue opening (window) in sleeping rooms that leads directly to the outside. Additionally, the IRC requires a primary means of egress (front door). NFPA 5000 does not require the primary door to be a side-hinged door. However, the IRC requires the primary means of escape to be a side-hinged door. Thus, a sliding door would be considered nonconforming.

For single-family dwellings, the primary means of escape (door) is required to be at least 32 inches wide by the IRC and NFPA 5000. Egress width for hallways in multi-family dwellings and commercial structures is dependent on the number of occupants served by that exit travel path.

Stories above or below grade level must be provided with means of egress. The most traditional means of egress is a stairway. Elevators are not typically considered a means of egress. Model building codes maintain specific requirements for stair geometry, handrails, guards, and minimum widths depending on the number of occupants. Multi-family dwellings and commercial multi-story structures require two independent means of egress. In older structures, this second means of egress may be by an exterior fire escape stair.

4.6.2.2 Potential Temporary Standards After a Disaster

The temporary habitability standard proposed by SPUR (2012) suggest that in the immediate [post-disaster] earthquake period, "There must be at least one usable exit path from every occupied area. Inclined counterbalanced fire escapes that are fully operational may be used to provide the one clear exit path. It's also acceptable to use a path that's currently blocked by building contents or other nonstructural elements but that can readily be cleared."

One means of egress for single-family dwellings may be sufficient for habitability in the initial aftermath of an incident. More stringent requirements may be needed for larger buildings and certain occupancies. Egress conditions should be evaluated considering the initial damage state of the structure as well as the potential risk of impairment by a cascading incident. Commercial structures with required fire-resistant rated egress paths of travel will require additional scrutiny, i.e., a Detailed Evaluation rather than a Rapid Evaluation.

4.6.3 Accessibility for Persons with Disabilities, Access and Functional Needs, and Seniors

When evaluating the habitability of a building, it is important to consider the needs of the occupants that may include persons with disabilities, access and functional needs, and seniors. Examples for considerations are presented in the sidebar on the next page.

4.6.3.1 The Americans with Disabilities Act (ADA)

Title II of the *Americans with Disabilities Act*[21] (ADA) applies to state and local government entities and protects qualified individuals with disabilities from discrimination on the basis of disability in services, programs, and activities provided by State and local government entities. Title II requirements will play a major role when it comes to programmatic access, effective communication, and physical accessibility access after a disaster.

Title III of the law prohibits "places of public accommodation" from discriminating against individuals with disabilities. A place of public accommodation is the terminology used by the ADA that describes a business that is generally open to the public, such as restaurants, hotels, sports arenas, beauty salons, and grocery stores. If the private owner invites the public into the building, then the ADA has jurisdiction. Title III sets minimum standards for accessibility for alterations and new construction. Essentially every new structure that serves as a place of public

[21] https://www.ada.gov/2010_regs.htm

> **Examples of Post-disaster Situations for Persons with Disabilities, Access and Functional Needs, and Seniors**
>
> A person with certain medical conditions may require electrical power for breathing devices or for powering a scooter or a wheelchair. If power cannot be restored, a portable generator may be necessary to ensure continuing in-situ habitability for this individual.
>
> Seniors, small children, and persons with medical conditions are more susceptible to temperature extremes, making portable heating or cooling devices essential.
>
> A user of a manual wheelchair may not need electrical power but will have an immediate need to have doorways and ramps cleared of debris, as will a person who is blind or has low vision.
>
> Effects of an event on the site (i.e., sidewalks, driveways), such as liquefaction after an earthquake, scouring after a flood, or sand deposits after a hurricane, will also impact the ability of persons with disabilities to leave their residences.
>
> If the sanitary sewer system is compromised and neighborhood portable toilets are deemed to be an acceptable alternative, then accessible units also need to be provided.

accommodation is required to be accessible while requirements for existing structures vary.

With ADA in place since 1990, newer commercial structures have likely been built in compliance; therefore, the issue of maintaining accessibility in a post-disaster environment is of critical importance, especially for persons with access and functional needs. The United States Access Board[22] is responsible for developing and updating the design guidelines known as the *ADA Accessibility Guidelines*[23] (ADAAG), used in setting enforceable standards that building owners must follow. Accessibility requirements have also been incorporated into building codes, such as the *International Building Code*.

According to *ADA Certification of State and Local Accessibility Requirements*[24], "Facilities that must comply with the ADA Standards may also be required to comply with accessibility requirements established under state or local laws. There are thousands of jurisdictions in the United States that adopt or enforce building codes, some of which also include accessibility requirements. Although many state codes are based on national models, *there can be significant variations among the state and local code requirements.* Design and construction under state and local codes complies with the ADA only when the codes provide accessibility that equals or exceeds the ADA requirements. When these laws are inconsistent, the burden falls on building owners and design professionals to ensure compliance with both federal and state laws."

4.6.3.2 The Fair Housing Act

New multi-family dwellings and those built since passage of the *Fair Housing Amendments Act* (i.e., occupied after March 1991) are required to comply with the accessibility provisions of the *Act*, which requires that most housing is designed to be accessible, with the exception of owner-occupied buildings with less than four units (four-flat, triplex, duplex and single-family dwellings). The *Act* requires non-exempt multi-family dwellings be designed and constructed with the following accessible features:

- The public and common use areas must be readily accessible to and usable by persons with disabilities.

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22 https://www.access-board.gov/

23 https://www.access-board.gov/guidelines-and-standards/buildings-and-sites/about-the-ada-standards/background/adaag

24 https://www.ada.gov/certcode.htm

- All doors designed to allow passage into and within all premises of covered dwellings must be sufficiently wide to allow passage by persons with disabilities, including persons who use wheelchairs.
- All premises within covered dwellings must contain the following features:
  - An accessible building entrance on an accessible route
  - Accessible common and public use areas
  - Usable doors (usable by a person in a wheelchair)
  - Accessible route into and through the dwelling unit
  - Light switches, electrical outlets, thermostats and other environmental controls in accessible locations
  - Reinforced walls in bathrooms for later installation of grab bars
  - Usable kitchens and bathrooms

4.6.3.3 Pre-disaster Requirements

The following permanent standards were identified:

- The Rehabilitation Act of 1973—*Architectural Barriers Act (ABA) Accessibility Guidelines*
- *Standard for Accessible and Usable Buildings and Facilities*, ICC A117.1 2017, International Code Council
- *International Existing Building Code*, International Code Council
- ADA *Checklist for Existing Facilities*, available at: https://www.adachecklist.org/doc/fullchecklist/ada-checklist.pdf

4.6.3.4 Issues to Consider

Consumer Perspective Narrative Analysis of a Disaster Preparedness and Emergency Response Survey from Persons with Mobility Impairments (Rooney and White, 2007), present the following lessons from Superstorm Sandy:

- *Regular support is the baseline. When an incident occurs, additional support will be required for persons with access and functional needs. This requires prior planning to anticipate support needs.*
- *Some transportation systems that people with mobility disabilities relied upon were unavailable after Super Storm Sandy (e.g., city bus routes were cancelled or modified). Accessible transportation should be provided.*

- *Timely services are required in some cases. Medical needs or services, such as oxygen delivery services, dialysis transportation, access to pharmacies, etc., need to be available in a timely manner as these can be a matter of life or death for vulnerable individuals.*
- *Elevator operation was problematic. Alternatives, such as stair-travel devices that do not require emergency personnel, should be considered. An inability to enter or exit multistory residences due to inoperable elevators deters access to apartments in high-rise buildings.*
- *Sheltering facilities have greater needs and support. Emergency shelters provide needed spaces and services, but some shelters were not accessible for persons with mobility disabilities after Super Storm Sandy.*

Phibbs et al. (2012) surveyed impacted individuals after the 2010-2011 Canterbury Earthquake Sequence and noted similar issues such as:

- "… Emergency service response did not adequately cater to the needs of disabled people."
- "Disabled people said that information provided did not cater for their needs and that much of the printed material did not adhere to the accessibility guidelines."
- "Consideration of ways to enhance mobility and lessen the impact of changes to public transport for disabled people should also be addressed as a priority."
- "Review of the safety of some disability accessible equipment is needed for emergency situations such as keyless door locks."

The Phibbs et al. (2012) study also found, based on international literature, that persons with disabilities are more likely to need to evacuate to a welfare center, yet they are less likely to do so. Based on comments from their own interview respondents, Phibbs et al. (2012) also found that individuals with disabilities may be reluctant to evacuate to welfare centers. It may be more difficult for people with disabilities to abandon their home because it might be the one place that is organized to suit their specific needs.

Phibbs et al. (2012) also contains an extensive reference section of related studies, both from New Zealand as well as the rest of the world.

4.6.3.5 Temporary Standards After a Disaster

No temporary standards were identified. Permanent requirements, listed in Sections 4.6.3.1, 4.6.3.2, and 4.6.3.3, may be considered during the restoration phase, depending on the extent of damage, the type of building (use), ownership (private vs. governmental), and the funding mechanism of the repairs.

Accessible dwelling units, both multi-family and detached, single-family dwellings, will need to be assessed on an individual basis. Every incident will be unique. If a structure only has one accessible entry and route to it, it must be intact and usable, substituting an alternate exit may not be a viable option.

A structure that was not ADA-compliant prior to an incident is not likely to be required to become accessible during the aftermath of an incident. However, when the structure is repaired or remodeled, alterations to the facility could trigger requirements to comply with accessibility standards.

4.6.4 Security

4.6.4.1 Pre-disaster Building Code Requirements

In Maslow's Hierarchy of Needs (Maslow, 1943), safety is only second to physiological needs such as food, water, and shelter. For incident survivors, being in their own home or neighborhood can provide emotional security, even if the structures do not meet minimum code requirements. These are issues that should be seriously considered by local governments when evaluating potential temporary habitability standards.

Pre-disaster building code requirements for security typically involve door locking hardware requirements. Building codes are primarily concerned with people being able to escape from a building as quickly and easily as possible. While the doors and windows of residences *are not required* to have locks, most people would not consider construction complete without these devices, just as they would not accept a house without carpeting, tile, or hardwood floor coverings (also not required by the code). Commercial construction locking device requirements vary depending on the number of occupants and the intended use of the structure. Regarding security, both residential and commercial codes require that "egress doors shall be readily openable from inside the dwelling without the use of a key or special knowledge or effort" (ICC, 2018d). The code acknowledges that special uses, such as correctional facilities, will need to be secured and thus grants permission to install locks—but then adds requirements for release in an emergency.

Some municipalities have adopted security provisions for their communities, requiring specific locks on doors and windows and may regulate bars on windows and doors as well (there are commercially available quick-release options for window bars that allow emergency escape from homes). For example, *Seaside* [California] *Municipal Code* (Seaside, 2019) Chapter 15.24 requires locks on single-family dwellings, garages, and residential units in apartment buildings; locks on sliding glass doors and windows. *Seaside Municipal Code* also has provisions for commercial buildings, which include locks, accordion grates, rolling overhead doors, and burglary-resistant glass.

4.6.4.2 Issues to Consider

Post-disaster security requirements will need to be evaluated based on any local amendments made by the AHJ at the time of the adoption of their building code. The level of security deemed necessary by the residents or businessowners themselves will likely drive the choices made to secure their structures, regardless of any potential temporary standard that may be established. Perhaps the most critical issue is not mandating security, but rather ensuring that whatever level of security chosen complies with the spirit of the building code, i.e., emergency escape is absolutely critical, especially in disaster-compromised buildings.

The post-disaster habitability of structures may need to consider the use of increased police and/or fire department presence for the time frame that is practical. Police may be unavailable to provide security in all locations. In past incidents, residents have established their own watches and have worked to control or limit ingress into damaged neighborhoods due to the fear of looting. After Hurricane Katrina, the National Guard was deployed to Biloxi, Mississippi to limit access to the waterfront.

Given that a structure may be partially open or unsecured, increased police patrols, or cordoning an area may provide added security. Additionally, standards have to be addressed individually to determine what it would take to provide minimum security for those individuals. Boarding open windows of wall openings, making a temporary door, or isolating a portion of the structure could be considered when evaluating the overall habitability of a building.

Since each resident will have been impacted differently and views security or safety differently, this should be discussed and reconciled, along with the other addressed alternative temporary habitability standards, prior to occupancy.

4.6.4.3 Potential Temporary Standards after a Disaster

Habitability of a residential structure or use and occupancy of a commercial building will be determined in part on the structure’s ability to shelter the occupants from the weather. This would imply a minimum of intact walls, roof/ceiling and windows or doors that are either in place or have been covered (e.g., plywood). Once the building envelope has been secured, locking mechanisms for doors and windows would be addressed. Given the dangers of fire in a post-disaster environment, any locks on the interior of a building should comply with the provisions of the building code.

4.7 Application to Non-Residential Occupancy Types

The guidance provided in the previous sections was primarily based on residential building codes. However, many of the hazards and considerations discussed apply to non-residential occupancy types as well.

The building codes have developed specific requirements based on the type of use intended for the structure. These requirements are the result of past experiences that revealed inadequacies in systems, such as exiting the building, fire protection, and smoke control.

Many of the same issues (water availability, sanitary facilities, light and power) that are key to the habitability of residential structures are also necessary for buildings with different occupancy types. Further, if the building is of a larger size, such as an office building, it can contain more people, and thus ensuring adequate exiting is essential. Due to the complicated nature of some occupancy types, it will be necessary that the AHJ determine the acceptability of habitability after a disaster.

4.8 Framework for Developing Temporary Habitability Policies

This section presents a possible framework for developing policies for temporary habitability. It includes discussion of the concept and benefits of post-disaster interim use of residential buildings, an example temporary habitability standard, key questions communities need to address in developing policies, and options for implementing temporary habitability policies. Although the primary focus on temporary habitability standards has been on interim use of residential buildings, habitability standards can cover all occupancy types, as discussed in Section 4.7.

After a disaster, providing temporary housing aids in keeping people connected with their community, limits the number of people who choose to or who are forced to relocate, and aids in recovery.

Where safe and practicable, temporary habitability policies may enable residents to return to or remain in their homes as a form of shelter until such time as permanent repairs are completed, thereby reducing the number of individuals in general population shelters or requiring assistance through non-congregate sheltering programs. While the concepts described in this section may be considered as a form of sheltering, there are many other well-defined terms and shelter types that are all part of the greater emergency management goal of providing shelter, before, during, and after disasters. These include evacuation and shelter-in-place[25], safe rooms[26] for tornadoes and hurricanes, and mass care[27]. These well-defined shelter types are governed by relevant guidance and standards, and the policies discussed in this section do not apply.

4.8.1 Interim Post-disaster Use of Residential Buildings

Lessons from earthquakes in New Zealand and Japan, Hurricane Katrina and Superstorm Sandy (Johnson and Olshansky, 2017; SPUR, 2012) point to the importance of developing policies and procedures that can allow residents to remain in their homes or return to their homes. Allowing residents to use their own damaged homes after a disaster if acceptable safety standards are met can provide a level of community stability, reduce the risk of long-term population displacement, and help to jump-start household and community recovery.

Displacement of residents can divide communities and separate people from their homes, possessions, assets, and lives. In Kobe, Japan, seniors displaced to remote temporary housing were found to have a significantly higher mortality rate than seniors who remained in the fold of their communities (Noritoshi, 1996). Housing habitability became a major policy touchstone in Christchurch, New Zealand following the 2010-2011 Canterbury Earthquake Sequence (Johnson and Olshansky, 2017). Many homes in areas of significant liquefaction and related ground failure were tipped, settled, or otherwise damaged, but did not necessarily pose life safety hazards. Utility services were generally disrupted due to broken underground lines and piping. Nonetheless, hundreds of residents chose to remain in their damaged, and disconnected homes and relied on temporary water and sanitation support and services.

Some building safety experts believe it is unreasonable to expect that damaged structures can meet all of the many code requirements of health and safety. Interim use is particularly difficult to implement in buildings of five-

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[25] *Planning Considerations: Evacuation and Shelter-in-Place*: https://www.fema.gov/media-library/assets/documents/181495

[26] FEMA P-361, *Safe Rooms for Tornadoes and Hurricanes*: https://www.fema.gov/media-library/assets/documents/3140

[27] NFPA 1616, *Standard on Mass Evacuation, Sheltering, and Re-entry Programs*: https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1616

or-more stories, sometimes considered to be “elevator buildings.” In such buildings, provision of the many support needs following a significant event is unreasonable or impossible, such as uninterrupted elevator service, temporary toilets and showers, water, and many other needs. Temporary habitability standards supporting occupancy of buildings might have conditions and services less than required by regular codes and standards. Some critical features that might be compromised during early weeks or months of interim use may include flush toilets or usable second exits.

To support occupancy of buildings that might have conditions and services less than required by regular codes and standards, temporary habitability standards should be flexible and adopted to suit the goals and expectations of the specific affected communities. Local variability might be in the requirements or in timeframes, milestones, and deadlines. Timeframe expectations, based on response and recovery to emergencies, such as recent hurricanes in recent decades in Louisiana and Puerto Rico, and earthquakes around the world, show that a reasonable phased approach, beginning with a simple provision of shelter and moving to full code compliance over time, might span months or even years. An additional challenge for a phased timeframe is addressing a “reset” in the timeframe in case of a significant follow-on or secondary event, such as a large earthquake aftershock.

Temporary habitability standards that allow residents interim use of residential buildings need to consider implementation dependencies, including assurance of acceptable safety, provision of necessary support, such as utilities and services, and effective communications between residents and supporting agencies. Special care and services must be provided for children, seniors, and persons with disabilities and special medical needs.

Household pets, service and assistance animals should also be accommodated and provided with services, including food, waste disposal, and veterinary care. The *Pets Evacuation and Transportation Standards Act*[28] (PETS) was passed in 2006 amending the *Stafford Act* to ensure that state and local preparedness and emergency operation plans address the needs of individuals with household pets and service and assistance animals, as well as authorizing federal assistance for the rescue, care, shelter, and essential needs of these same individuals and their pets and service and assistance animals, prior to, during, or following a major disaster or emergency.

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[28] https://www.congress.gov/bill/109th-congress/house-bill/03858

Immediately following an incident, non-residential buildings may also be used as housing. This use would likely include persons staying in offices, businesses, or schools overnight until they could safely return to their homes or other more appropriate shelters. Some non-residential uses have made provisions for such emergency use, such as fire, police, hospitals, and emergency operations facilities. These facilities clearly have special need to maintain function in emergency and recovery periods. Some other structures are easily adapted to short-term occupancy of employees and other workers, especially if they already serve a short-term guest use, such as hotels.

Most non-residential structures provide few or none of the basics and amenities of home, with no beds, showers, or food preparation and service areas. It would be unusual for a building that was not provided with basic residential services to continue to be used as shelter for more than one or two days. It would be particularly problematic to attempt to shelter on an upper floor of a tall building, as lack of elevator service and utility disruptions are likely to make difficult conditions even more onerous. Not having residential basics, however, will not stop people from adapting to available conditions, such as sleeping wherever is most comfortable.

Support for short-term shelter in non-residential facilities might be provided by maintaining information connectivity through provision of media and internet services, along with charging ability for personal electronics. Such shelter is, of course, very short term, and people will need to understand the conditions of their homes and communities to make plans for their next move.

While encouraging employees and others to be generally prepared for emergencies, it might be unreasonable to expect that operators of non-residential structures could make provisions for such rare and unknown circumstances. If sufficient advance notice is available, such as with an impending severe weather event, and not all personnel are evacuated, some provisions could be made for emergency use.

4.8.2 Example Temporary Habitability Standard after a Disaster

The SPUR (2012) policy report presents the concept of phased habitability where recovery of capacity progresses over time (Figure 4-4). Although the SPUR report was developed for recovery following an earthquake in San Francisco, the idea can apply to other incident types in other areas.

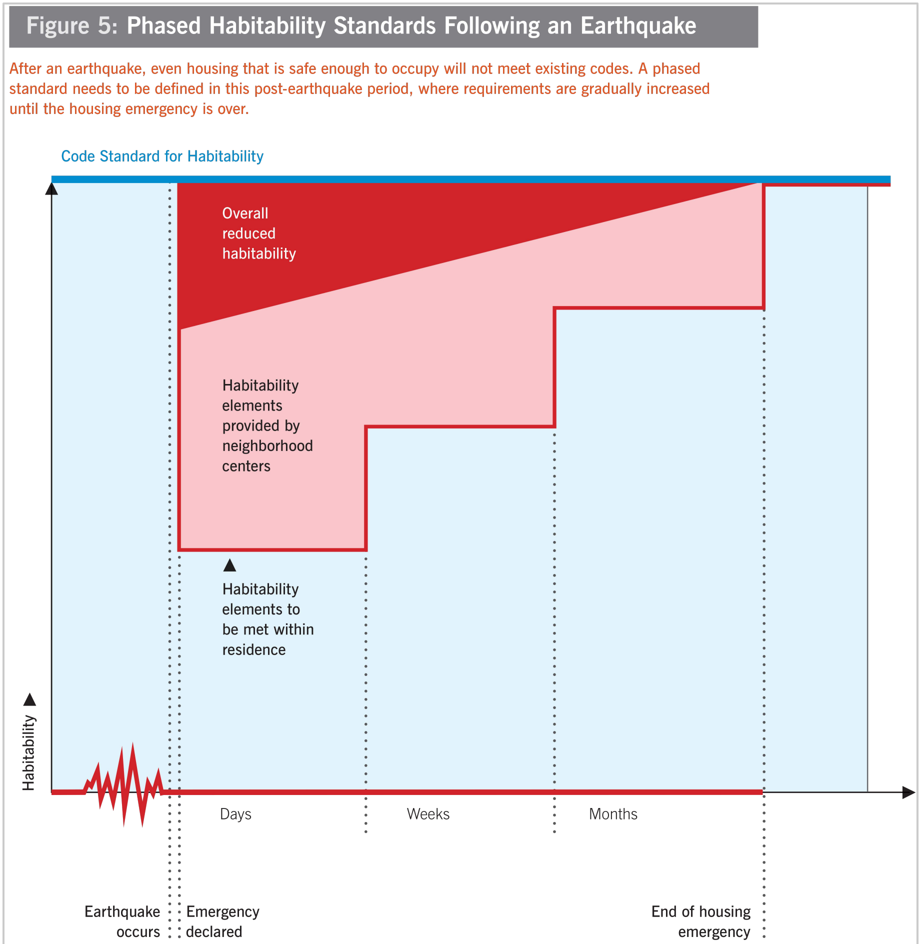

Figure 4-4 Phased habitability recovery (from SPUR, 2012).

Figure 4-4 shows that habitability requirements at different milestones are fulfilled over time. Immediately after the earthquake, SPUR (2012) proposes the use of neighborhood support centers to provide necessary help for communities staying in their homes. These centers are not envisioned to serve as mass care shelters that provide living space, but instead, as a neighborhood resource for important services and information to encourage people to stay in their own homes. Services for supporting interim use of residential buildings either on site or at neighborhood support centers can include:

- Weatherproof shelter at acceptable temperatures
- Food and water
- Basic safety and security
- Waste disposal
- Other necessary utility services such as electricity

- Communications facilities, including high-speed internet and locations for device charging
- Comfort
- Animal care
- Health care as needed, including refrigeration for medications
- Information from jurisdiction and other responsible support agencies
- Spiritual support as requested
- Psychological support, including counselors and friends
- Social support, such as community gathering and eating areas
- Financial services of all sorts
- Transportation facilities
- Repair support and services, including necessary building materials and supplies
- Privacy and support of self-determination
- Plans for progress toward community restoration
- Activities, such as talks, movies, meetings

As time elapses, habitability requirements for interim use of residential buildings can be adjusted. Figure 4-5 from SPUR (2012) shows an example of expected conditions immediately, one week, one month, three months after the earthquake. After the housing emergency is over, all pre-disaster habitability requirements are expected to apply.

Figure 6: An Alternative Habitability Standard

In the post-earthquake period, an alternative habitability standard will need to be defined. This standard will need to take into account the safety of the housing unit, the need for weather protection and the availability of utilities.

Immediate post-earthquake period	
The building must be safe.	Safety will be defined by an engineering tool (ATC-20) that has been modified by the city. Residents will not be permitted to occupy buildings or portions of buildings posted as unsafe. Prior to a formal inspection by an authorized person, owners and tenants may self-inspect using a simplified checklist to be provided by the city.
There must be at least one usable exit path from every occupied area.	Inclined counterbalanced fire escapes that are fully operational may be used to provide the one clear exit path. It's also acceptable to use a path that's currently blocked by building contents or other nonstructural elements but that can readily be cleared.
One week after the earthquake. *Meet all the conditions above, plus the following:*	
Portable fire extinguishers	Must be in place if required for multifamily residences.
Weather protection: roof	May be a temporary plastic covering.
Weather protection: walls	May be a temporary plastic covering.
Weather protection: windows	May be a temporary plastic covering.
Provision of a building address	May be a temporary address placard.
Smoke detectors	Battery-powered okay.
CO2 detectors	Battery-powered okay.
Elevators in buildings of five or more stories	Must work seven days following restoration of electrical service.
One month after the earthquake. *Meet all the conditions above, plus the following:*	
Electricity	Must work 30 days following restoration of service.
Gas	Must work 30 days following restoration of service.
Sewer and toilet	Must work in home 30 days following restoration of service. Where sewers are not working or pipes are leaking, waste must be bagged, treated with chemicals and disposed of according to local instructions. For more information, see sewersmart.org/disrupted.html
Water	Must work 30 days following restoration of service.
Fire alarm systems and other required alarms	Must work 30 days following restoration of electrical service.
Emergency exit illumination	Must work 30 days following restoration of electrical service.
Electrical light: at least one fixed or cord-and-plug type per room	Must work 30 days following restoration of electrical service.
Hot water supply	Must work 30 days following restoration of service of water and gas/electric.
Refrigeration for food	Must work 30 days following restoration of electrical service.
Three months after the earthquake. *Meet all the conditions above, plus the following:*	
Automatic fire sprinklers, sprinkler wet standpipes and fire pumps	Must work 90 days following restoration of water service.
Entrance doors and hardware/locks	Must work 90 days after the earthquake.
Second exit, if required	Fire escapes are acceptable as second exits.
Heating service	Must work 90 days following restoration of utility service.
After the housing emergency is over. *All normal habitability requirements will apply at the end of the declared housing-emergency period.*	

Figure 4-5 Example temporary (or alternative) habitability standard (from SPUR, 2012).

4.8.3 Issues to Consider in Developing Temporary Habitability Standards

Development of a temporary habitability standard for a community requires making decisions and setting policies on many issues. These issues will vary by community, the incident type and scale, available resources, the time of year and weather conditions, and many other factors. However, there are common questions that apply to many situations. To help give communities and their leaders a start on the issues, a series of questions are listed below, together with associated discussion.

4.8.3.1 Technical Questions

- Egress: Is a second means of escape needed? Does it depend on the size of or number of stories in the building?
- Fire Suppression: Are fire alarms required? Are fire sprinklers required? Fire alarm and fire sprinklers are of particular concern to many, but is a fire watch an acceptable temporary standard? This is the typical approach used outside of disasters when fire alarms and sprinklers are temporarily inoperable. Does it depend on anticipated fire department response times?
- Carbon Monoxide: Are carbon monoxide sensors required?
- Elevator: How many stories are acceptable without a working elevator?
- Power: Is power required? Does it need to be continuous?
- Light: How much lighting is required? Are battery-powered lights sufficient?
- Heat: Is heat required? Should it depend on the climate? Is there a target thermal range?
- Water and Sewer: Is access to water and sewer required in the building? If these services are provided nearby in the neighborhood, is that sufficient? Centralized neighborhood facilities have been used in past incidents, but it is still desirable to have shelters for vulnerable populations.
- Security: Does the building have to be lockable? It may be appropriate for a homeowner to choose whether they stay in their home if it is not lockable, but there is generally more discomfort with this in a large building, like a multi-family residential building. People may be less inclined to leave their home if it is not lockable, as they want to remain to protect their belongings for fear of looting. Buildings with electronic locking mechanisms may pose special issues when electrical service is down.
- Access for Persons with Disabilities: What aspects of accessible building design are required? Is an accessible path required if there was one before?
- Communications: Access to phone communications or the internet is an integral part of modern life, but there are no building code requirements. Should there be any requirements for phone and/or internet access?

4.8.3.2 Administrative and Policy Questions

- Milestones: What are the milestones of relevance between the disaster and the full return to permanent standards? SPUR (2012) proposes the following milestones: (1) immediately after event; (2) one week after the event; (3) one month after the event; (4) three months after the event; and (5) at the end of the declared emergency. These may be too rapid to be realistic for major incidents. It will also depend on what is specifically required at each milestone.
- Scale: The extent and severity of an incident are likely to impact what is considered acceptable for temporary standards. A bigger disaster could lead to lower requirements because the need to compromise is greater. What are the alternatives in place? How long will the disaster take to resolve?
- Incident Type: Should habitability requirements vary by incident type? Are there issues specific to only some incidents, like damage from flood waters?
- Occupancy Type: Is it appropriate or desirable to have different requirements depending on the occupancy? For example, requirements for single-family dwellings may be more permissive than those for multi-family residential buildings because it is not uncommon to let homeowners make choices about issues that affect only or primarily only their families; but tenants in multi-family residential buildings may have limited say in a choice made by the building owner. Moreover, tenants and occupants in multi-family residential buildings also have limited say in choices made by other tenants and occupants, which is one of the reasons why multi-family residences are more heavily regulated than single-family residences and temporary standards may need to be more stringent. Standards may also need to be more stringent in buildings open to the public that serve important functions in recovery, like grocery stores, pharmacies, and hardware stores. Requirements for a public school building might be more conservative since students are required to attend the school. On the other hand, this needs to be balanced against the need to open schools quickly to restore community functioning and promote family and household recovery.
- Evaluator Qualifications and Resources: Who has the skill set to make detailed habitability evaluations? Are qualified environmental health specialists, hazard material teams, building code officials, and other specialists available?

- Pre-incident Deficiencies: What should be done if the building services and systems and other code issues were already not in compliance with permanent standards before the incident? This will be a common occurrence in older buildings that were built to different standards.
- Authority to Permit Occupancy: Who makes the decision to permit occupancy in buildings without fully functioning building systems? Is this the building official? Can they delegate this authority? Can they allow reduced occupant loads, such as when the number of functioning means of egress and escape is temporarily reduced?
- Enforcement: Who would enforce temporary habitability requirements during the recovery period? Is enforcement practical?
- Changing or Removing a Placard: Who has the authority to change or remove a placard? Is repair to the pre-existing condition sufficient, even if that condition was not compliant with the current code. For example, should a severely deficient building (e.g., an unretrofitted unreinforced masonry building) be allowed to be restored to pre-event conditions, or should it be required to be retrofitted?
- Communication:
    - Building safety placards such as those from ATC-20-1 and ATC-45 occasionally identify significant environmental hazards or blocked exit paths and restrict access until they are addressed, but they have not typically been applied to damage to building systems and services or some code deficiencies like a compromised accessible path or a damaged fire rated corridor which go beyond the scope of the typical post-disaster building safety evaluation. Environmental hazard and building system and service evaluation, or relevant code deficiencies evaluations will be done by others. How will restrictions they identify be communicated to the building owner and occupants?
    - In some cases, the building official may allow a compromised building to be occupied. Building owners should share information with the occupants about the damage and what systems are compromised. Standardized communication language should be developed to address how to describe the relevant deficiencies and options for occupants.
- Conflicting Laws: Are there laws that need to be changed to permit a temporary habitability standard, including those that relate to building, fire, and health and safety codes?

- Stakeholder and Community Engagement: Which stakeholders may be most resistant to the concept of a temporary habitability standard? What will change their mind? Stakeholders include owners, occupants, tenants, and government agencies such as police, fire, health, and building departments. Community-wide engagement is also needed.

4.8.4 Approach Options for Implementing Temporary Habitability Policies

There are various significant potential conflicts in adopting or applying temporary habitability standards. Jurisdictions might be limited in legal authority to provide alternate codes and standards, even in emergencies. For example, in California, the authority to adopt alternate or emergency health and safety standards is restricted to the state legislature in adopting *California Health and Safety Code*[29] provisions. In such cases, actions to support interim post-disaster use of residential housing might be affected by adjusting inspection priorities through the general authorities that are given to enforcement agencies. Inspection priorities might include policies directing inspectors to check only for limited requirements, such as provision of at least one exit.

Other challenges to the use of temporary habitability standards might come from other agencies, such as fire departments that might not condone the use of any structure that does not meet all fire safety regulations, or building owners who have concerns about the liability of allowing occupancy of buildings that do not fully comply with regular codes. Their concerns must be addressed, typically through discussion, adopted policies, and implementation compromises. Clearly stating occupancy regulations on a defined timeline will do much to relieve stress in the lives of building owners and users.

There are several implementation approaches that a community might consider taking after addressing the key questions indicated in Section 4.8.3. These include the following, from the most limited to the most comprehensive:

- Option 1: An ad hoc response to each incident, without discussion, pre-planning, or policies. This is not recommended.
- Option 2: Assignment of habitability evaluation responsibilities during pre-planning efforts, but no formal habitability policy regarding reoccupancy requirements: In this approach, the community's emergency plan identifies who has responsibility for environmental

[29] https://leginfo.legislature.ca.gov/faces/codes.xhtml

evaluations and building systems and code issue evaluations. This might include the fire department, emergency services department, hazardous materials teams, department of health, and building department. In this approach, decisions would be made on a case-specific basis following the evaluations; there would not be any advance guidelines or requirements in place.

- Option 3: Adoption of a habitability policy setting milestones and targets for a select set of key building services and systems: This approach would include the pre-planning efforts of assignment of evaluation responsibility in Option 2, and there would also be milestones and targets for more critical building services such fire and life safety systems. Phased goals for these systems would be identified such as an initial fire watch, followed by fire alarms restarting, followed by fire sprinklers returning to operation. These would be goals, but they would not be enforced. Signage or placards could be utilized to post buildings with information regarding environmental hazards and building system issues and recommendations, but these signs would not force any mandatory actions.
- Option 4: Adoption of a habitability policy setting milestones and targets for addressing a comprehensive set of building systems and other code requirements: This would be similar to Option 3, except that there would be a much broader extent of building systems and services and code issues that were included in the scope of the policy.
- Option 5: Adoption of a temporary habitability standard with enforcement: This would be the most comprehensive approach. It would cover the scope of Option 4, but it would include enforcement of restrictions. Signage or placarding would be more likely in this option and could include signs that have restrictions against reoccupancy until the temporary standard is met. Government agencies—such as police, fire, the building department and the department of health—would perform periodic inspections to confirm the standard is being met.

Chapter 5

Pre-disaster Program Management

5.1 Overview

Post-disaster building safety and habitability evaluations will benefit from planning and careful overall management of the process. This chapter provides guidance on planning a post-disaster evaluation program before an incident occurs. Issues occurring during the conduct of a program after the incident are addressed in Chapter 6.

Topics in this chapter include discussion of prudent planning activities in Section 5.2, identification of appropriate personnel to involve in an evaluation program and their responsibilities (known as "resource typing") in Section 5.3, and related certification and training requirements for evaluators and other personnel involved in the evaluation process in Section 5.4. Section 5.5 discusses how mutual aid is used to share resources from those outside the disaster region to those jurisdictions in need. Section 5.6 reviews how volunteer evaluators are integrated into the evaluation process, how liability may be mitigated through Good Samaritan laws, and how workers' compensation is applied to those in the evaluation process. Section 5.7 provides recommendations on laws and policies that are needed to improve the effectiveness of post-disaster building evaluations.

Table 5-1 provides a summary of best practice guidance, interim recommendations, and additional discussion and needs for pre-disaster program management presented in each section. Key terms, acronyms, and references are defined within the body of each section.

Table 5-1 Pre-disaster Program Management Best Practice Summary

Section	Topic	Best Practice	Interim Recommendation	Additional Discussion/Needs/Comments
5.2	Pre-planning	None	This *Guide* and the Cal OES *SAP Coordinator Manual*	None
5.3	Resource typing	NIMS *Resource Typing Library Tool* provided by the FEMA NIC	Not applicable	• NIMS resource typing required by DRRA Section 1241(b) was coordinated with the 1241(a) effort. The following new resource definitions are expected to be issued: ◦ Post-disaster Building Safety Evaluation Strike Team Technical Supervisor to provide technical oversight, quality assurance, and deployment prioritization of safety evaluations. ◦ Post-disaster Complex Structural Condition Evaluator to provide evaluations of structurally complex buildings or conditions. ◦ Post-disaster Complex Architectural Systems Condition Evaluator to provide evaluations of architecturally complex buildings and architectural systems (such as fire safety systems, environmental systems, building envelope systems, communication systems, and accessibility and building transportation systems), and to determine impacts on habitability and occupancy.
5.4	Certification and training	Cal OES SAP training program for safety evaluators	Building officials and other local officials responsible for coordinating building safety and evaluation functions should take recognized post-disaster safety evaluation training.	• Enhance Cal OES program beyond earthquake/wind/flooding. Develop higher level certification and training program for a Post-disaster Complex Structural Condition Evaluator that focuses on the Detailed Evaluation method and for a Post-disaster Complex Architectural Systems Condition Evaluator. • Apply consistent approach across the U.S. • Require ICC Building Official Certification to include post-disaster safety evaluation. • Develop curriculum for post-disaster building safety evaluation as part of emergency management and disaster science education programs.
5.5	Mutual aid resources and agreements	EMAC	Not applicable	EMAC legislation has been enacted in all 50 states.
5.6	Volunteers, liability, Good Samaritan laws, and workers' compensation	None	AIA and ACEC model language	A number of states need to pass laws to provide consistent volunteer protection.
5.7	Laws and policies	Not Applicable	Pass legislation where missing in the community.	• Pass Good Samaritan Laws. • Pass legislation to provide authority to (1) evaluate and post buildings, (2) deputize evaluators, (3) restrict occupancy, and (4) demolish buildings.

5.2 Pre-planning

Each emergency management plan adopted by a state, local, tribal, or territorial government should contain a section, chapter, or annex addressing evaluation of buildings following an incident that might have impacted the safety and habitability of buildings. In general practice, the post-disaster building safety evaluation section of the emergency management plan would be developed by the local emergency manager with the assistance of the local authority having jurisdiction (AHJ) over building construction within that jurisdiction. It is likely that the plan will be written with the point of view of damage assessment to ensure consistency with FEMA. The emergency plan can also be expanded to address disaster recovery, codes and regulations, shelters, temporary housing, permits, repairs, rebuilding, and relocation of structures if needed.

The post-disaster building safety evaluation section of an emergency management plan can address the following points:

- Purpose and scope
- Situation and assumptions
  - Critical or essential facilities (may also be identified in the Local Hazard Mitigation Plan)
  - Critical infrastructure (may also be identified in the Local Hazard Mitigation Plan)
  - Community support facilities (such as pharmacy or grocery stores)
  - Ability to restrict pedestrian movement, traffic, and/or occupancy in and around damaged structures with cordons and barricades
- Concept of operations
  - Scheduling of damage assessment or evaluation
  - Levels of damage and safety evaluation
  - Windshield survey
  - Rapid Evaluations
  - Detailed Evaluations
  - Direction and control
  - Resource typing in accordance with FEMA National Incident Management System (NIMS)

- Damage assessment manager who oversees post-earthquake building safety evaluations and other activities such as preliminary damage assessments
  - Damage assessment team composition
- Assignment of responsibilities
  - Organizational chart
  - Contact information
- Additional aid documentation
  - Contact information for outside agencies (such as mutual aid sources)
  - Qualifications and services of outside agencies
- Training and certification necessary (also refer to Section 5.4 of this *Guide*)
  - For Rapid Evaluation of structures
  - For Detailed Evaluation of structures
  - For Detailed Evaluation of critical structures
  - For evaluation of infrastructure
  - Distribution of identification to evaluators
- Forms and data collection
- Interconnected or relevant plan sections for reference

Gaps in planning can delay the requests and deployment of evaluation teams following an incident, potentially endangering the public or slowing the reoccupancy process.

Interim Recommendation

Communities should develop emergency management plans that address post-disaster building safety evaluations. The discussion in this report provides interim recommendations on incorporation of a post-disaster building safety evaluation plan into a jurisdiction's emergency management plan. The California Governor's Office of Emergency Services (Cal OES) *Safety Assessment Program (SAP) Coordinator Manual* (Cal OES, 2016b) provides additional helpful guidance.

5.3 Resource Typing

As previously described in Section 2.6, universally accepted plain language, as used in NIMS, with associated capabilities, is integral for sharing resources among jurisdictions. Resource typing definitions provide minimum criteria for team and personnel capabilities and qualifications and should be used by jurisdictions and organizations to identify, type, and inventory their teams and personnel. Resource typing definitions can be used to assess the capabilities of existing teams and personnel against those defined.

When requesting a resource through mutual aid, jurisdictions and organizations can request a specific type of resource, ensuring that the resource will meet the minimum capabilities in the resource typing definition. This way, all parties understand the capability of the team or personnel requested and the resource can meet the mission requirements. Jurisdictions can easily provide appropriate resources using their typed inventory.

Building safety evaluation techniques are scalable and the resource typing definitions reflect this. If a single vehicle collides with a building, a building safety evaluation can be performed on that individual building. If an earthquake or hurricane damages thousands of buildings and impacts a large regional area, building safety evaluation techniques can be scaled up to meet that demand, requiring additional specialists, such as geographic information system (GIS) specialists or unmanned aerial vehicle (drones) technical specialists to increase capabilities to meet complex incident needs.

Best Practice

Jurisdictions and organizations should adhere to NIMS concepts and principles. Jurisdictions and organizations should conduct exercises to improve the common understanding of building safety evaluation capabilities and to improve resource sharing and mutual aid procedures. Building safety evaluations benefit from this common language, with a more universal understanding of teams, evaluation capabilities, and qualified personnel to perform evaluations.

The definitions as published on the FEMA NIMS *Resource Typing Library Tool*[1] should be used to:

- Identify and type resources
- Qualify, certify, and credential personnel

[1] https://rtlt.preptoolkit.org

- Plan for resources
- Acquire, store, and inventory resources

As required by *Disaster Recovery Reform Act* (DRRA) Section 1241(b), the FEMA National Integration Center (NIC) will issue new guidance to ensure the functions of post-disaster building safety evaluation, such as those functions performed by design professionals, are accurately resource typed within NIMS. The FEMA NIC effort has involved the participation of the authors of this *Guide* to achieve coordination and consistency.

Resource types have been developed for the following resources, and post-disaster building safety evaluation programs should utilize these resources. Specific and comprehensive details for each resource will be provided on the NIMS *Resource Typing Library Tool*. A summary and discussion for each resource is given here.

Post-disaster Building Safety Evaluator

Post-disaster Building Safety Evaluators conduct Rapid Evaluations and Detailed Evaluations of buildings. They work in two-person teams in the field. ATC-20-1 and ATC-45 both provide recommendations on the qualifications of evaluators for Rapid and Detailed Evaluations. The ATC-20-1 and ATC-45 recommendations are similar, but not identical; they are brief and general; and they identify preferred and alternative qualifications. For example, ATC-20-1 identifies the "Suggested Personnel" for Rapid Evaluations as building inspectors, civil/structural engineers, architects, and disaster workers. For Detailed Evaluations, the team consists "ideally" of structural engineers. However, another good team consists of one structural engineer and one building official. If structural engineers are not available, building inspectors and architects can serve on the team.

The recent NIMS resource typing effort is more specific and is expected to identify three types of Post-disaster Building Safety Evaluators. All require training in post-disaster building safety evaluation and the Incident Command System.

- A Type 1 evaluator can lead a Detailed Evaluation team, and is a licensed structural engineer, professional engineer with a specialization in structures, or registered architect and has five years of experience in building design and analysis, including evaluation of existing buildings, field investigation, and construction observation.
- A Type 2 evaluator can lead a Rapid Evaluation team, and is a licensed structural engineer, professional engineer with a specialization in

structures, or registered architect; or a certified building official, building inspector, or plans examiner with four years of experience in building design or analysis, including evaluation of existing buildings, field investigation, or general construction, construction observation, or inspection experience.

- A Type 3 evaluator can assist on a Rapid or Detailed Evaluation team and includes individuals with a bachelor's degree in civil or structural engineering, or architecture and those with four years of experience in building design or analysis, evaluation of existing buildings, field investigation, or general construction, construction observation or inspection. The Type 3 evaluator is intended to include contractors with appropriate general construction experience.

Evaluators with past post-disaster building safety evaluation experience are desirable, but they may not be available. Available resources will need to be appropriately deployed depending on the specific incident, damage level and scale, and building stock.

Post-disaster Building Safety Evaluation Strike Team Leader

The Team Leader manages the Building Safety Evaluation Strike Team, with responsibility for administration, staffing, deployment decisions, coordination with other resources outside the team, and coordination of Strike Team activities within the Incident Command System (ICS) structure. Per the recent NIMS resource typing effort, it is expected that the Team Leader should have at least two years of leadership and supervisory experience and training and experience consistent with the Type 2 Building Safety Evaluator. The building official for the AHJ in the area impacted by the incident is a likely candidate to serve as the Team Leader as they will already be familiar with the jurisdiction, the building stock, and organizational structure of the government. If the incident is too large, and the local building official is unavailable, an experienced building official from another community, but with general knowledge of the impacted community, may be a good alternative.

Post-disaster Building Safety Evaluation Strike Team Technical Supervisor

The Technical Supervisor reports to the Team Leader. The Technical Supervisor's role is to provide enhanced quality assurance and more consistent results in the post-disaster evaluation process. Responsibilities include answering questions regarding evaluation criteria, procedures, and appropriate conclusions and language to use on placards; performing spot checks of submitted evaluations in the field and in damage photos; helping to choose when to perform Detailed Evaluations; identifying trends that are common in the incident and how to properly evaluate them; and advising on upcoming deployment priorities. Per the recent NIMS resource typing effort, it is expected that the Technical Supervisor should be a Type 1 Building Safety Evaluator and have had experience with post-disaster building safety deployments. The Technical Supervisor may be a structural engineer, but this is not a requirement; what is important is that the supervisor has the requisite experience and expertise to perform the tasks identified above. An experienced professional engineer with a specialization in structures may be an acceptable candidate, as well as an experienced architect with detailed knowledge of structural systems. Knowledge of specialized building practices for incident-specific hazards and knowledge of damage impacts of incident-specific hazards are required. Knowledge of local building construction practices is highly desirable. The Technical Supervisor position and the Team Leader position could be fulfilled by the same individual when the scale of the incident is not too large, but the Team Leader primarily has administrative and logistical responsibility, while the Technical Supervisor has technical oversight responsibility.

Post-disaster Complex Structural Condition Evaluator

Training for Building Safety Evaluators focuses on the Rapid Evaluation method, which is the typical approach used for most buildings. For more complicated structures, a higher level of experience, training, and certification are recommended that focus on the Detailed Evaluation method. The Complex Structural Condition Evaluator would be selectively deployed to evaluate structurally complex buildings or conditions in incident areas. The Complex Structural Condition Evaluator is a licensed structural engineer or professional engineer with a specialization in structures, and has at least ten years of combined experience in building design and analysis, including evaluation of existing structures, field investigation, and construction observation. It is desirable if the Complex Structural Condition Evaluator has deployment experience with post-disaster building safety evaluations. They will be called on to help evaluate the most difficult and significant conditions of structural damage.

Post-disaster Complex Architectural System Condition Evaluator

The Complex Architectural System Condition Evaluator conducts evaluations of architecturally complex buildings and architectural systems (such as fire safety systems, environmental systems, building envelope systems, communication systems, accessibility systems, and building transportation systems), to determine impacts on habitability and occupancy. Building types include high-rises, mixed-use facilities, hospitals, schools, shopping malls, hotels and convention centers, large business complexes, and historic structures. They evaluate the impact on habitability from loss of function to systems that include fire protection (active, e.g., suppression; and passive, e.g., fire-rated assembly elements), exiting and egress, accessibility, building envelope (cladding and roofing), environmental systems, building transportations systems (e.g., elevators), on-site energy generation (solar), and communication/alarm systems.

The Complex Architectural Systems Condition Evaluator is a licensed architect, or a certified building official, building inspector, or plans examiner, with a bachelor's degree in construction, fire protection management, engineering, or architecture. They have at least ten years of experience in the architectural design of complex building types, field investigation, and construction observation or ten years of experience as an International Code Council (ICC) commercial plans examiner with commercial construction field inspection experience for a major metropolitan jurisdiction. They will be called on to help evaluate challenging situations, such as when egress or fire protection systems are partially compromised, or when accessibility requirements are not fully met.

Post-disaster Building Safety Evaluation Team

The Evaluation Team is made up of two people that perform the field evaluations and post buildings. Typically, they are comprised of two Post-disaster Building Safety Evaluators. The number of teams will depend on the scale of the incident and the extent of damage. In some cases, a team will be comprised of a Post-disaster Building Complex Structural Condition Evaluator and a Post-disaster Building Safety Evaluator. In other cases, a team will be comprised of a Post-disaster Complex Architectural Systems Condition Evaluator and a Post-disaster Building Safety Evaluator.

Post-disaster Building Safety Evaluation Strike Team

The term "Strike Team" is defined in NIMS as a set number of resources of the same kind that have an established minimum number of personnel, common communications, and a leader. Post-disaster Building Safety Evaluation Strike Team describes the entire collection of resources assigned to conduct and manage post-disaster building safety evaluations. To allow for flexibility and scalability based on incident needs, the Post-disaster Building Safety Evaluation Strike Team is not a NIMS-typed resource. At a minimum, it will typically include the Post-disaster Building Safety

Evaluation Strike Team Leader, the Strike Team Technical Supervisor, and a set of two-person Evaluation Teams of Building Safety Evaluators. In larger, urban incidents, there may be a small number of Evaluation Teams that include a Post-disaster Building Complex Structural Condition Evaluator or a Post-disaster Complex Architectural Systems Condition Evaluator.

Organization Chart

Figure 5-1 shows an example organization chart for the Post-disaster Building Safety Evaluation Strike Team, including the above resources. The team will report to Incident Command or General Staff in the Incident Command System. As noted above, some Strike Teams may not include the resources in the green boxes.

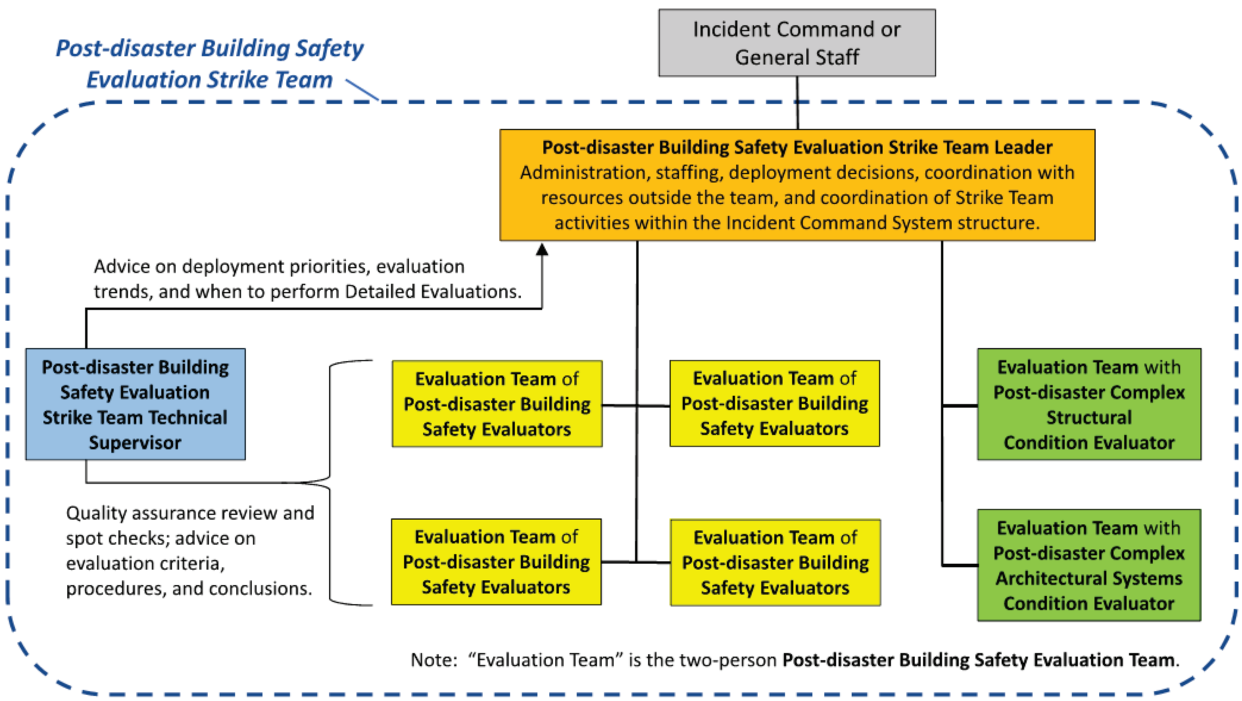

Figure 5-1 Example organization chart for the Post-disaster Building Safety Evaluation Strike Team.

Additional Resource Types

Depending on the types of incident that are being planned for, or responded to, the following existing resource types in the FEMA NIMS *Resource Typing Library Tool* may also be considered as potential members of building safety evaluation teams:

- Geological Specialist
- Geological Survey Team
- GIS—Specialist, Team, Supervisor, Technician, Analysis
- Environmental Health Specialist

It is recommended that additional positions be considered for future development as additional needs in the field arise.

5.4 Certification and Training

5.4.1 Post-disaster Building Safety Evaluators

The FEMA ICS is a management system designed to enable effective and efficient domestic incident management by integrating a combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure. ICS is used by emergency management professionals at all levels (local, state, and regional), and at the national level through the use of NIMS. NIMS defines operational systems, including the ICS, emergency operations center (EOC) structures, and Multiagency Coordination Groups (MAC Groups) that guide how personnel work together during incidents. NIMS applies to all incidents, from traffic accidents to major disasters. The FEMA NIMS Training Program[2] identifies those courses critical to train personnel capable of implementing all functions of emergency management. This program establishes the NIMS core curriculum to ensure it adequately trains emergency and incident response personnel to all concepts and principles of each NIMS component. The following online training courses are offered by FEMA:

- NIMS/ICS IS-100, *Introduction to ICS*
- NIMS/ICS IS-200, *ICS for Single Resources and Initial Action Incidents*
- NIMS/ICS IS-700, *National Incident Management System, an Introduction*
- NIMS/ICS IS-800, *National Response Framework, an Introduction*

A basic knowledge of ICS and NIMS programs provides a common language and is necessary for Building Safety Evaluators so that they can successfully integrate into, and understand their role in, an incident response plan.

A number of organizations across the country offer training and/or certification programs in building safety evaluation. These organizations recognize that Building Safety Evaluators need experience, training, and a professional connection to the built environment. Certification, training, and credentialing are viewed as methods to ensure consistency in the evaluation process.

[2] https://www.fema.gov/nims-training

California Governor's Office of Emergency Services (Cal OES) offers Safety Assessment Program (SAP)[3] training and certification to professionals so that they can assist local governments in safety evaluation of their built environment in the aftermath of an earthquake. Cal OES SAP also provides limited coverage on building safety evaluations following windstorm and flood events but does not include other incident types. Programs across the country vary in the level of professional knowledge, training, and expertise required. Many programs utilize the Cal OES SAP training as the foundation for their program. One common element of these programs is that the certification, training, and credentialing they provide are generally considered optional, and are rarely required of engineers, architects, or building officials by their employers.

Following an incident, building officials are typically the first to deploy after an incident as they are employed by the affected jurisdiction and are local. Building officials are trained (nationally) and typically certified through the International Code Council[4] (ICC). Other professionals involved in evaluation are often engineers or architects who are licensed to practice in a specific state, thus state-wide programs are one of the organizational structures frequently seen.

The following is a summary of selected certification and training programs:

- California Governor's Office of Emergency Services (Cal OES):
    - Cal OES offers SAP training and certification to professionals.
    - SAP identification cards are issued for certification expire five years from the month of the evaluator class.
    - An online refresher training course is offered for individuals who are already registered with SAP.
    - One of the following credentials is required in order for a person to be registered into the statewide SAP cadre:
        - Professionally registered civil, structural, or geotechnical engineers (from any state)
        - Professionally licensed architects (from any state)
        - Professionally registered geologists or engineering geologists

[3] https://www.caloes.ca.gov/cal-oes-divisions/recovery/disaster-mitigation-technical-support/technical-assistance/safety-assessment-program
[4] https://www.iccsafe.org

        - Certified building inspectors or officials as follows: Building Inspector (ICC), Building Plans Examiner (ICC), Combination Inspector (ICC) Certified Building Official (ICC), Commercial Building Inspector (ICC), Master Code Professional (ICC), Residential Building Inspector (ICC), Residential Combination Inspector (ICC), Combination Dwelling Inspector (ICC), Combination Plans Examiner (ICC), Combination Plans Examiner (ICC), Building Code Official (ICC), Construction Inspector Division II (American Construction Inspectors Association, ACIA), Division of the State Architect Class 1 & 2, and OSHPD Class A; or Certified public works inspectors with a Construction Inspector Division IV certificate (ACIA)

    - Two types of certificates are provided: SAP Evaluator and SAP Coordinator. In addition, a train-the-trainer course is offered to expand the number of approved instructors. Cal OES reserves the right to train trainers and will only provide credentials to individuals who have been trained by Cal OES.

    - SAP is managed by Cal OES. Professional organizations may offer courses by Cal OES approved instructors.

    - Cal OES issues registration ID cards to all SAP evaluators that have successfully completed the program requirements. Training for this program is eligible for Homeland Security Grant Program funding.

    - As a state-run program, reliant on state funding, access to this training by stakeholders in other states is not guaranteed.

- International Code Council (ICC):

    - ICC provides training to its members through its two-day, in-person When Disaster Strikes Institute. The course utilizes the ICC WDS *Field Manual* 1419S along with ATC-45 and ATC-20-1 documents.

    - In the past, the training prepared participants to become an ICC nationally certified Disaster Response Inspector (DRI), but ICC no longer offers this certification. Upon completion of the course, attendees receive a certificate that allows them to apply for credentialing through Cal OES SAP.

- Applied Technology Council[5] (ATC)

    - ATC provides training seminars for both ATC-20-1 and ATC-45 procedures.

[5] https://atcouncil.org/training-info1

  - ATC does not have a certification program, but training courses can be delivered on request, including the option for the trainees to complete a course with an instructor who has completed the Cal OES SAP trainer program, allowing the trainees to apply towards a Cal OES certification.
- American Institute of Architects[6] (AIA)
  - AIA utilizes the Cal OES SAP training curriculum with additional information on the AIA Disaster Assistance Program.
  - AIA does not have a certification program, but instructors who have completed the Cal OES SAP trainer program deliver the course, allowing the trainees to apply towards a Cal OES certification.
  - To supplement Cal OES SAP training, the AIA recommends that volunteers take FEMA ICS courses NIMS/ICS IS-100, NIMS/ICS IS-200, IS-700, and NIMS/ICS IS-800.
- National Council of Structural Engineers Associations[7] (NCSEA)
  - The Structural Engineering Emergency Response (SEER) Committee of NCSEA focuses efforts on four main areas: training, roster management, assistance coordination, and advocacy. The training provided by or through NCSEA currently consists of the Cal OES SAP program, in addition to ICC's When Disaster Strikes Institute.
  - In order to be deployable through NCSEA/Disaster Response Alliance programs, operations training as defined in the draft FEMA Resource Type is required. This training includes, but is not limited to, the NIMS coursework listed above.
- Missouri Structural Assessment and Visual Evaluation[8] (SAVE) Coalition
  - SAVE utilizes their own training programs, based on ATC-20-1. SAVE has their own program for wind safety evaluations that pre-dates ATC-45. SAVE does not provide any flood safety evaluation training.
  - SAVE has developed its own Coordinator Training (called On-Site Leader Training) for volunteers to manage deployments and data.

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[6] https://www.aia.org/
[7] http://www.ncsea.com/
[8] https://sema.dps.mo.gov/programs/SAVEcoalition.php

- Washington Safety Assessment Facility Evaluators[9] (WAsafe) Program
  - The WAsafe program utilizes ATC-20-1 training with added elements of Cal OES and ATC-45 training, as well as state-specific procedures and laws. Training is conducted by the Washington Association of Building Officials, Structural Engineers Association of Washington and by the AIA.

Best Practice

Cal OES offers SAP training and certification to professionals so that they can assist local governments in safety evaluation of their built environment in the aftermath of an earthquake.

Additional Discussion and Needs

A number of professional organizations and governmental agencies provide essential training and education for their members and allied professionals. Each program has its strengths and weaknesses. Cal OES offers a robust program to respond to earthquakes and over the years has added sections on windstorms and flooding. ICC training mentions other types of events but still does not contemplate all of the hazards that will affect the built environment. A beneficial activity would be to determine the scope of each program (e.g., structural only, structural and habitability, occupancy driven), and review of the strengths, weaknesses, and gaps of each program, its training, testing, certification, credentialing, and requirements for continuing education re-certification.

In the interim, the summary provided in this *Guide* provides guidance to local jurisdictions seeking the most appropriate evaluators for the incident. In the long term, the summary would help identify programs that could be modified or enhanced to provide a holistic training and certification approach to ensure a robust level of knowledge and experience in the responders.

In the longer term, a consistent approach to certification and training throughout the United States would be a desirable goal. As with any type of training program, funding models and grant support will be necessary to develop, update, and maintain the training programs so they reflect lessons learned from recent incidents, including nonstructural safety concerns and habitability considerations discussed in Chapter 4, and research from FEMA Mitigation Assessment Team and Building Performance Assessment Team reports. In addition, training programs and certification for the Post-disaster Complex Structural Condition Evaluator and Post-disaster Complex

[9] https://www.wabo.org/emergency-management

Architectural Systems Condition Evaluator roles discussed in Section 5.3 are needed that go beyond the typical training programs described above.

5.4.2 Emergency Management Personnel

The resources and skills offered by evaluation programs are only effective when strategically deployed. However, post-disaster building safety evaluations are not typically referenced in college-level courses on emergency management and disaster science, and no formal curriculum is dedicated to this part of disaster response. Thus, it can be overlooked in local emergency management plans and may not be part of the organizational flow in an EOC. Depending on the size of the jurisdiction and the size of the incident, it does not take much for a local jurisdiction to be overwhelmed. Outside police and fire emergency responders may deploy to the region immediately, but outside building safety evaluation personnel must likely be requested. This action can be overlooked or not well understood by emergency managers or Incident Command.

Local building officials or emergency managers responsible for developing the safety and damage evaluation portions of emergency management plans often lack formal training regarding the aspects of performing evaluations and for coordinating larger-scale evaluation teams.

Interim Recommendations

Emergency management personnel need education on the details of post-disaster building safety evaluation as a key component of emergency response planning to ensure public safety as well as an effective and efficient response following an incident.

To improve local response, local officials responsible for performing or coordinating building safety and damage evaluation functions can be encouraged to attend recognized training courses for building safety evaluation and coordination. Additionally, ICC provides a nationally-recognized Certified Building Officials certification. A recommended prerequisite to obtain the certification could be completion of a safety evaluation or coordination training session.

Additional Discussion and Needs

To improve the knowledge base for emergency management professionals, curriculum should be developed for emergency management and disaster science education programs on post-disaster building safety evaluation planning as part of the overall emergency management plan and how architects, engineers, building officials, and other design professionals can be accessed to assist with this important task.

5.5 Mutual Aid Resources and Agreements

The concept of post-disaster building safety evaluations generally relies upon the ability of an affected jurisdiction to reach out beyond their borders to obtain resources from unaffected areas to assist with the required response. This is known as "mutual aid." Resources may include equipment, supplies, or personnel.

Some states, such as California (Cal OES SAP) and Missouri (SAVE Coalition), have established the ability to make mutual aid requests for personnel to perform post-disaster building safety evaluations through codified processes that address liability protection and portability of licensure.

Some mutual aid agreements are pre-established procedures adopted by adjacent jurisdictions that agree to assist each other in times of emergency need; whereas mutual aid can also be delivered through just-in-time operational methodologies that provide for more robust capability.

5.5.1 Emergency Management Assistance Compact

One such just-in-time system, and the primary nationwide mutual aid system in the United States, is the Emergency Management Assistance Compact[10] (EMAC).

All 50 states, the District of Columbia, Puerto Rico, Guam, and the U.S. Virgin Islands have enacted legislation to become EMAC members. Membership in EMAC allows for any of these affected states or territories to make requests from other states via their emergency management office under the authority of the governor of the state.

EMAC establishes a common language and universal system for providing assistance under pre-agreed terms and conditions. By participating through EMAC, responders who leave their home jurisdiction are eligible for tort liability protection, workers' compensation protection, license/certification reciprocity (portability of licensure outside their home state or states where they have a license) and reimbursement.

NIMS resource typing definitions are recommended for use in the EMAC process, as either standalone requests or as part of an EMAC Mission Ready Package (MRP). Further, in order for private sector assets (equipment or personnel) to deploy through EMAC, the private sector entity must have an agreement (typically a formal memorandum of understanding (MOU)) in

[10] https://www.emacweb.org/

place with the host emergency management agency to form a Mobile Support Unit (MSU) that is able to deploy. These MOUs should outline the terms of the private sector professional's involvement, including but not limited to, duration of the deployment, insurance coverages, limits of liability, rates of reimbursement, etc. The individual components of the MSU (personnel and equipment) should meet the FEMA NIMS resource typing definitions associated with that type of asset.

5.5.2 Other Mutual Aid Systems

There are other regional and intra-state mutual aid agreements in place throughout the United States and elsewhere. It is a central concept of any organization's emergency response plan. It should be noted, however, that unless specifically defined by legislation for that jurisdiction, the above-referenced benefits of liability protection, portability of licensure, and reimbursements may not exist for responders participating in these mutual aid systems.

Best Practice

EMAC legislation has been enacted in 50 states, the District of Columbia, Puerto Rico, Guam, and the U.S. Virgin Islands.

Additional Discussion and Needs

Although EMAC provides the framework for significant force multipliers and mutual aid through engaging private sector resources, not all states have embraced the concept of utilizing private sector personnel. It would be beneficial to engage the private sector to make post-disaster building safety evaluations successful.

A mechanism should be established so state governments can easily provide workers' compensation and liability insurance requirements that are implicit to an EMAC response.

In addition, the establishment of MOUs between state-level professional associations (e.g., state-level chapters of AIA[11], NCSEA[12], ASCE[13], ICC[14]) and their respective state emergency management office (or another sponsoring agency) may facilitate more streamlined mechanisms for reimbursement of private sector personnel who engage in post-disaster building safety evaluations via EMAC. These state-level organizations could

[11] https://www.aia.org/
[12] http://www.ncsea.com/
[13] https://www.asce.org/
[14] https://www.iccsafe.org/

also engage in exercises and training with the various state response agencies so that integration of the private sector resources is more seamless during times of an incident.

Lastly, the concept of establishing MRPs for post-disaster building safety evaluation could be explored in an attempt to expedite the response of evaluators following a disaster. An MRP is similar to a resource type team specification, but also addresses operational and logistical requirements of a response (including, but not limited to: mission statements, limitations of the resource type or MRP, required support from other sources, response time and duration, personnel costs, equipment costs, travel and other related costs). EMAC has tools available to assist with developing MRPs.

5.6 Volunteers, Liability, Good Samaritan Laws, and Workers' Compensation

Architects and engineers are obligated under their respective licensure board rules of professional conduct to protect public health, safety, and welfare. In times of natural disasters or other catastrophic incidents, architectural and engineering expertise and skills are needed to provide structural, mechanical, electrical, or other architectural or engineering services to determine the integrity of structures, buildings, piping, or other systems. Architects and professional engineers are often called upon to voluntarily assist their communities, states, and the nation in these times of crisis.

In 2012, FEMA published *Citizen Corps Volunteer Liability Guide* (FEMA, 2012), a comprehensive guide that includes liability and Good Samaritan laws, workers' compensation, risk management and ways to improve state laws affecting volunteer liability. The report needs to be updated regarding specifics, but the basic information is sound.

5.6.1 Good Samaritan Laws

Legislation needs to be in place to protect architects and engineers from civil litigation for the volunteer services they render in an emergency upon request by an AHJ. This legislation is commonly known as a Good Samaritan Law and, at a minimum, should include the following:

- Legislation must provide civil immunity for architects and engineers.
- Voluntary professional services are provided during or within 90 days of a natural disaster or catastrophe (time frame can be extended if necessary).
- The services are provided under the applicable license or certification and are related to the natural disaster or catastrophe.

- Services are provided at the request of a federal, state, or local public official, law enforcement official, public safety official or building inspection official.
- No immunity is provided for wanton, willful, or intentional misconduct.

Impacted volunteers who are post-disaster building safety evaluators are described as follows by Cal OES (2016a):

- Volunteers:
  - Engineers with Professional Engineer (PE) or Structural Engineer (SE) licenses
  - Architects
  - Building Officials and building inspectors
- Qualifications:
  - Engineers and architects—licensed by state
  - Building Officials and building inspectors certified by ICC

Laws vary by state and by profession. Figure 5-2 shows a map of states where Good Samaritan laws are in place for architects in the United States.

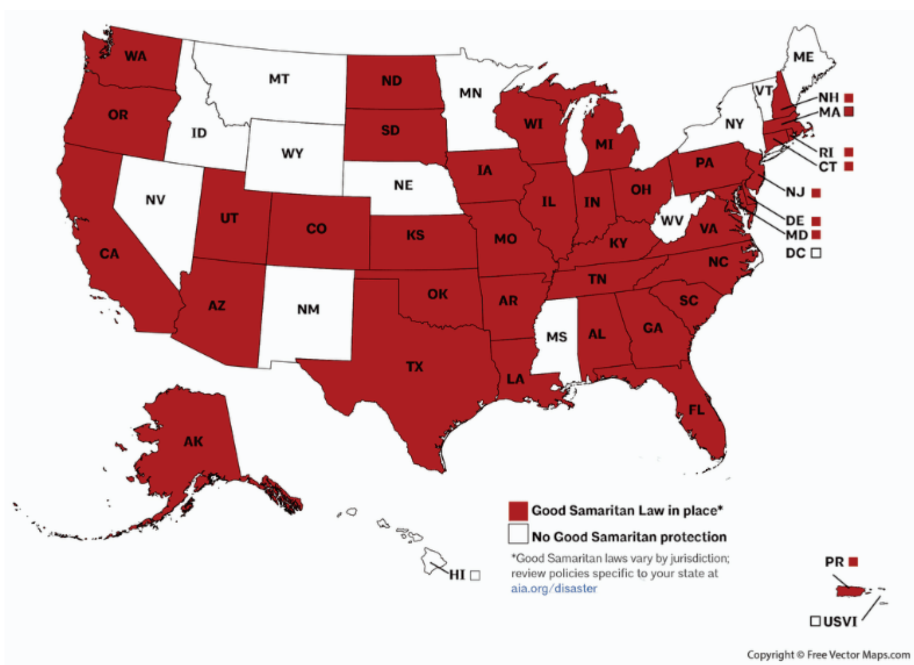

Figure 5-2 Map showing states with Good Samaritan Laws in place (AIA, Current as of 2019). Source: https://www.aia.org/resources/71641-good-samaritan-state-statute-compendium.

It is noted that the map in Figure 5-2 is current as of the publication date of this *Guide,* and evaluators should check with the requesting AHJ. The following states are considered to have comprehensive Good Samaritan statutes protecting professional engineers: California; Colorado; Florida; Georgia; Kentucky; Louisiana; Maryland; Michigan; North Carolina; North Dakota; Oregon; Virginia; and Washington. In addition, Kansas, Tennessee, and Utah offer protection for engineers who provide services under emergency situations caused by certain catastrophic incidents only, i.e., earthquakes or floods.

State laws vary greatly. The states that have passed Good Samaritan laws for design professionals (architects and engineers) are not uniform in who is covered, nor for what acts.

- The Alabama statute, Section 6-5-332(f), protects "any licensed engineer, licensed architect, licensed surveyor, licensed contractor, licensed subcontractor, or other individual working under the direct supervision of the licensed individual who participates in emergency response activities," without compensation, if the volunteer "acts as a reasonably prudent person would have acted under the same or similar circumstances."
- The Arkansas statute protects any "registered architect or professional engineer" who volunteers in a declared emergency except for wanton, willful, or intentional misconduct.
- In Colorado, state law similarly protects licensed architects or engineers who volunteer to provide architectural, damage evaluation, engineering, or surveying services, respectively, at the scene of an emergency, but not for acts constituting gross negligence or willful misconduct.
- The Illinois statute protects professional engineers, architects, land surveyors, and structural engineers, and their employers, from civil liability when they volunteer "during or within 60 days following the end of a disaster or catastrophic event." In tornado-prone states like Kansas and Missouri, architects and engineers are immune from liability for negligent structural inspections performed voluntarily after a natural disaster. The Missouri statute extends protection to "construction contractors, equipment dealers and other owners and operators of construction equipment" for actions taken as emergency volunteers.
- In Louisiana, licensed architects, professional engineers, and land surveyors are immune for "voluntary architectural, engineering, or land surveying services that occur during the emergency."

- Perhaps the broadest statute is found in Massachusetts, where the law grants immunity to licensed professional engineers, architects, environmental professionals, landscape architects, planners, land surveyors, or contractors, in addition to subcontractors and suppliers who volunteer in a natural disaster or catastrophe within 90 days of the end of the natural disaster or catastrophe.
- In Washington state, immunity protection is limited to those working under a state mission number, which means they must be working under the authority of the state or the local AHJ. An engineer or architect who voluntarily assesses a home or other building (for instance, as a favor in their neighborhood) and is not doing so as a volunteer under the local AHJ's authority, is not immune from liability.

5.6.2 Federal Volunteer Protection Act

The federal *Volunteer Protection Act* (VPA) of 1997 provides protection to volunteers from nonprofit organizations and governmental entities for harm caused by their acts or omissions on behalf of the organization or entity. VPA does not require that an emergency declaration be in place for its protections to apply. States may pass laws that are more restrictive.

VPA applies to an uncompensated volunteer for acts of ordinary negligence committed within the scope of the volunteer's responsibilities. If the volunteer's responsibilities are covered by licensure laws, the volunteer must be properly licensed, certified, or authorized by the appropriate authorities as required by the law in the state in which the harm occurred.

5.6.3 Workers' Compensation

AIA *Good Samaritan State Statute Compendium*[15] cautions architects to determine appropriate workers' compensation before evaluations commence—coverage is governed by the architects' home state—not the one they volunteer in. This caution would be similar for engineers, and, of course the laws and rules of each state may differ.

5.6.4 Portability of Licensure

Architects and engineers are licensed by each individual state rather than at a national level. Many architects and engineers are licensed in multiple states, but this is costly, and is typically undertaken only if the individual intends to regularly conduct business in more than one state. Additionally, some states limit practice to certain categories of licensed professionals.

[15] https://www.aia.org/resources/71641-good-samaritan-state-statute-compendium

During a large-scale incident, the legal limitations of professional practice can inhibit adequate response efforts that necessitate outside reinforcements to meet the need, as architects and engineers can be considered to be practicing without a license if they cross state lines. To overcome this typical legal barrier in a critical yet temporary situation, a state licensing board can advocate for policies that allow out-of-state design professionals serve as "emergency workers" during a formal emergency or disaster declaration period. In addition, Article 5 of EMAC provides temporary reciprocity for professional licenses for the purpose of disaster aid. Design professionals volunteering through the EMAC will be subject to the policies and protocols of the state-to-state agreement.)

Best Practice

There is no consistent legislation addressing these issues. There are some states that have excellent protections already in place.

Interim Recommendation

Good Samaritan State Statute Compendium (AIA, 2019) and *Good Samaritan Statutes for Design Professionals* (ACEC, 2019) provide sample model language that can be proposed to create legislation addressing these issues.

Using state architect or engineering professional organizations, all states could work towards adopting a strong Good Samaritan statute, perhaps one that updates and strengthens federal VPA to provide Good Samaritan protection in addition to addressing the state by state licensure issue. In addition, Good Samaritan provisions could be triggered for federal emergency and disaster declarations, requiring a state to adopt these protections in order to be eligible for federal disaster reimbursement funding.

Development of a robust tool can enable engineers and architects determine easily if the state where they will be assisting has a Good Samaritan law and any limitations of the law.

Additional Discussion and Needs

States should be encouraged to pass laws that protect design professionals in advance of a disaster, so that the affected areas can benefit from the knowledge, expertise, and training engineers and architects are able to provide in times of disaster. Passage of bills during non-emergency times allows for adequate training, credentialing, and the creation of an effective deployment strategy.

Resources

- *ASCE Emergency Responder Legislation*: https://www.asce.org/issues-and-advocacy/public-policy/policy-statement-536---emergency-responder-legislation/
- *Who Protects the Good Samaritans?*: https://www.structuremag.org/?p=13713
- *Volunteer Protection Acts and Good Samaritan Laws Fact Sheet*: http://www.astho.org/Programs/Preparedness/Public-Health-Emergency-Law/Emergency-Volunteer-Toolkit/Volunteer-Protection-Acts-and-Good-Samaritan-Laws-Fact-Sheet/

5.7 Necessary Laws and Policies

In incident response, jurisdictions that respond to disasters must have a strong legal basis for the actions that they take, as it is likely that some persons may disagree with directives and oppose or fail to voluntarily comply. Further, following an incident, there are likely to be public inquiries and legal challenges that require officials and others to be able to clearly state under what legal or policy/procedural basis and authorization they took key actions, such as barricading, building demolition, restrictions to entry or use, mandating residents to relocate, causing expensive damage while gaining access, or using private property for operational expediency. Careful documentation of all actions by emergency managers during incident response is essential to address such concerns, ideally using time stamped electronic communication or notes made in ink in a bound journal, with dates, times, persons, and actions briefly noted.

Coordination of mobilization of resources from other governmental agencies as well as from volunteer professional organizations, such as through mutual aid agreements, may require adopted policies in advance or at the time of need. See Section 5.5 for more information regarding this topic.

Jurisdictional emergency operations plans, typically prepared in advance of incident response, usually require official approval. Details of such plans will generally include topics related, but not limited, to emergency operations, continuity of government and services, utilization of standardized emergency systems, and standard operating procedures.

While authority for emergency jurisdictional actions may be in place, various overarching legal requirements will, of course, remain intact, such as individual legal protections granted by the U.S. Constitution. Whenever possible, property owners must be given opportunities to be heard regarding actions to be taken that affects their property, and to be given opportunities, when circumstances allow, to speak in opposition to proposed jurisdictional action.

Building and housing codes are typically adopted at the state, county, or local level, and provide minimum standards for habitability. Specific provisions in disaster declarations and related adopted emergency regulations may possibly supersede an adopted habitability regulation; this is a complicated subject to be addressed in coordination with jurisdictional legal staff. In an extreme case, a landlord may choose not to allow continued occupancy by tenants of a dwelling unit because it does not meet regular legal requirements for heat, water, power, or damage. For these reasons, it will be critical to have access to experienced legal assistance during an emergency to address issues related to emergency authority and to limit jurisdictional liability and legal challenges.

The Building Occupancy Resumption Program (BORP) implemented in the City and County of San Francisco provides authority for deputized private-sector architects and engineers, paid by building owner or users, to evaluate and post structures with official jurisdictional placards. Such a program, developed in advance and approved by the jurisdiction, can significantly decrease time to allowable occupancy and continued use of structures, as well as reduce demand for emergency inspection services. Without preapproval of such postings, authority to post official jurisdictional placards by private individuals, even when licensed as an architect or engineer, is strictly restricted. San Francisco is currently preparing legislation requiring BORP to be implemented for all newly constructed buildings over 240 feet.

Section 2.5 provides a review of building code provisions as they relate to post-disaster building safety evaluations and the authority that the building official can delegate if there are local procedures in place. It is likely that different jurisdictions may have different interpretations of the meaning and authority of these general code provisions. Jurisdictions looking to deputize or otherwise authorize inspectors should consult with legal advisers and regulatory staff persons to ensure that the jurisdiction and deputized inspectors, engineers, architects, and others are properly authorized and, as necessary, indemnified.

Interim Recommendation

In order to more effectively perform post-disaster building safety evaluations, a number of regulations might usefully be developed at the local level in advance of an emergency. They include the following:

- Authority to evaluate and post structures

- Adoption of evaluation program training materials, such as Cal OES SAP, ATC-20-1, or ATC-45
- Authority to deputize evaluators and other representatives of jurisdiction
- Authority to restrict entry and habitability of structures, including authority for police or other enforcement
- Authority, including procedures, for emergency enforcement of management determinations, such as structure demolitions
- Legal protection for the various persons and organizations who provide support for response (building official, engineer, and architect associations)
- Development of standardized programs such as San Francisco's BORP program, allowing building owners to hire independent engineers authorized by jurisdictions to provide building-specific evaluation and official placarding

Resources

- State of California, *Business and Professions Code*, *Division 3. Professions and Vocations Generally, Article 3. Application of Chapter*, Section 5536.27 (through 2012 Leg Sess)
- City and County of San Francisco, Business Occupancy Resumption Program (BORP) procedures. Available at: https://sfdbi.org/borp-guidelines-engineers

Chapter 6

Post-disaster Program Management and Implementation

6.1 Overview

This chapter discusses program management and implementation guidance issues that should be addressed following the disaster.

Topics in this chapter include implementation of the post-disaster building safety evaluation section of an emergency management plan in Section 6.2, safety considerations for deployment of evaluation personnel in the impacted region and useful field tools and resources in Section 6.3, establishing deployment priorities in Section 6.4, and requesting necessary deployment resources in Section 6.5. Data collection and reporting of the information acquired during the evaluation process, such as the building information and posting status, are covered in Section 6.6. Quality assurance techniques to improve the quality and consistency of the evaluations are discussed in Section 6.7. In many incidents, ongoing hazards, such as aftershocks, continuing floods, or subsequent snow and ice loads, may trigger the need for reevaluation. Section 6.8 discusses techniques for determining when evaluation personnel need to be redeployed to conduct reevaluations. Current safety evaluation documents, such as ATC-20-1 and ATC-45 focus on evaluating the implications of damage from the hazard; they do not cover in detail the process or criteria for how to change or remove a placard; this is discussed in Section 6.9. It is common practice to provide fencing, barricades, or cordons around damaged structures. There is, however, relatively limited technical guidance on how to do this. Section 6.10 reviews current practice and identifies needs. Finally, Section 6.11 covers communicating with the public, the media, and building owners and occupants.

Table 6-1 provides a summary by topic of best practice guidance, interim recommendations, and additional discussion and needs for management of a post-disaster building safety evaluation program.

Table 6-1 Post-disaster Program Management Best Practice Summary

Report Section	Topic	Best Practice	Interim Recommendation	Additional Discussion/Needs/Comments
6.2	Implementation of post-disaster safety evaluation plans	Develop safety evaluation plan for a specific incident, for inclusion in the incident action plan being utilized for the disaster.	None	The official in charge of managing the safety evaluation program should provide this information to the Incident Commander (or their appropriate Command Staff or General Staff.
6.3	Safety of evaluators and field tools and resources	This *Guide* identifies available resources.	Not applicable	Detailed safety guidance by incident type is needed.
6.4	Evaluation prioritization	None	This *Guide*	Develop targeted building safety evaluation teams for essential facilities, grocery and hardware stores, and pharmacies.
6.5	Deployment Resources	Some national organizations and states have processes available.	This *Guide*	Create national volunteer database.
6.6	Data collection and reporting	ATC-20-1 and ATC-45 evaluation forms	None	• Develop consistent list of data points to collect and report, including usability categories (see Chapter 3) and depth of flood water in structure on ATC-45 form. • An electronic tool that overcomes connectivity issues and standardizes data points, including those that are required for state and federal disaster declarations, would make data collection more efficient and accurate.
6.7	Quality assurance	None	Include Technical Supervisor role	• Develop quality assurance guidelines. • Post-disaster evaluation guidelines, such as ATC-20-1 and ATC-45, should be updated to show examples of inappropriate practices and/or provide warnings. • The Technical Supervisor has overall responsibility for quality assurance in the safety evaluation process.
6.8	Reevaluation triggers	None	Indicator buildings for earthquakes	• Increase building strong motion instrumentation coverage. • Develop guidance for other incident types.
6.9	Changing or removing a placard	None	Local jurisdiction develops own policy	Consensus and guidance are needed on (1) who has authority to reevaluate and change a rating; (2) whether a qualified private engineer or architect can be permitted to change ratings; (3) as aftershock, wind, flood, and fire risk diminish, can placard restrictions be relaxed; and (4) what is needed to go from UNSAFE to RESTRICTED USE and from RESTRICTED USE to INSPECTED.

Table 6-1 Post-disaster Program Management Best Practice Summary (continued)

Report Section	Topic	Best Practice	Interim Recommendation	Additional Discussion/Needs/Comments
6.10	Cordoning and barricading	2013 Interim Guidance document, California Building Officials (CALBO)	Not applicable	Update CALBO document to cover: (1) research on effectiveness of scaffold and barricades; (2) expanded stakeholder involvement and refinement of protection of public way and adjacent buildings; (3) specific criteria to permit more flexibility in fencing and barricade placement; and (4) required follow-up inspections.
6.11	Communication	None	AHJs should develop standard operating procedures for communication following incidents	None

6.2 Implementing the Post-disaster Safety Evaluation Section of the Emergency Management Plan

To speed recovery and reconstruction, post-disaster building safety evaluations should commence immediately following initial emergency response, search, and rescue. To initiate safety evaluations, the local official in charge of safety evaluation will follow the post-disaster safety evaluation section of the jurisdiction's emergency management plan, if available, and will modify the plan if needed based on the incident.

Preliminary information on the incident can be collected by windshield surveys, flyovers, and to some extent, dispatch calls and social media. After major earthquakes, the United States Geological Survey (USGS) rapidly posts onto its internet site[1] maps of shaking intensity and likely damage concentrations based on strong motion recordings. However, a visual survey of the area from the ground or by air is the most desirable. From that viewpoint, the local official can gather initial information such as:

- Damage to essential facilities such as hospitals, police stations, fire stations, and emergency operations centers, emergency shelters, aircraft control towers, power plants, water treatment facilities, and similar facilities.
- Damage to facilities that contain quantities of toxic materials.
- Damage to schools, childcare facilities, and nursing homes.
- Damage to important facilities such as grocery stores, gas stations, pharmacies, and home improvement stores that residents that stay in the area may need. Note that the *International Building Code* and

[1] https://earthquake.usgs.gov/earthquakes/

ASCE/SEI 7, *Minimum Design Loads for Buildings and Other Structures*, both have Risk Category tables that categorize buildings. Risk Category IV is where "essential" facilities are located. There is no formal "critical" category or designation. Schools are in Risk Category III. Grocery stores, pharmacies, and home improvement stores have no special designation. They are termed "important" facilities in this *Guide*.

- Possible damage to infrastructure such as electrical lines, water lines, natural gas lines, streets and bridges.
- Estimates on the number of residential and non-residential structures impacted.
- Limits of damage (e.g., from Street A at east limit to Street M at west limit and from river at south to water tower at north). This information will start the mapping process for damage evaluation planning.

With the above information collected, the local official can determine:

- When it will be safe to deploy safety evaluation teams (Section 6.3)
- Prioritization of evaluations (Section 6.4)
- Necessary deployment resources (Section 6.5)

Best Practice

Following the development of the safety evaluation plan for a specific incident, the official in charge of managing the safety evaluation program should provide this information to the Incident Commander (or their appropriate Command Staff or General Staff) for inclusion in the incident action plan.

6.3 Deployment Safety and Tools

Safety evaluation activities can be hazardous. Following an incident, public safety and emergency health resources are already strained and should not be put to additional pressure by deploying safety evaluation teams when it is not safe to do so.

It is recommended that the following be confirmed before deploying evaluators:

- The local official in charge of safety evaluation and/or the Post-disaster Building Safety Evaluation Strike Team Leader described in detail in Section 5.3 should confirm that evaluation personnel can safely get to and from the damaged area and are instructed on safety protocol prior to deployment in the field. The considerations should include human effects, such as rioting, looting, and civil unrest, that can pose a threat to evaluators.

- Deployed safety evaluators should be trained on what to expect in the field and how to prepare themselves with appropriate personal protective equipment based on the field conditions and disaster type.
- Deployed safety evaluators need to be physically capable of working long hours in disaster environments. Evaluators should see a medical professional to assess their fitness of duty before volunteering.

6.3.1 Recommended Equipment for Personal Safety of Evaluators

The National Institute of Environmental Health Sciences (NIEHS, 2019) and U.S. Department of Labor Occupational Safety and Health Administration (OSHA, 2019) provide lists of personal protective equipment for use in impacted areas, as well as additional recommendations. A summary of equipment is given below. Some adaptation to different incidents and situations may be needed. The list of equipment may include the following:

- Steel toe/shank work boots
- High visibility vest
- Durable, disposable gloves
- ANSI certified hard hat
- Lantern
- Headlamp, batteries
- Hand sanitizers, disinfectant wipes
- P100 or N95 respirators (for those medically approved to wear respirators and fit-tested to the specific respirator)
- Safety glasses/goggles
- First aid kit
- Over-the-counter medications (e.g., anti-diarrhea)
- Mosquito and tick repellant
- Sunscreen
- Snake bite kit
- Device chargers
- GPS units

- Ready-to-eat meals (MRE)
- Cases of bottled water
- Cooler and ice

6.3.2 Safety from Environmental Hazards

Chapter 4 described environmental hazards that may result from incidents. The following are safety considerations due to environmental hazards that may apply for any incident type:

- Lacerations, slips, trips and falls from handling and walking over debris are a hazard in any incident type (NIOSH (2007) reported that during Hurricane Katrina recovery efforts, the biggest risk was these type of injuries). Evaluators should stay alert and watch where they walk.
- If there is the smell of natural gas, the evaluator should leave the building by the fastest route possible, using stairs, not elevators, and notify the fire department, utility, or authorized representative immediately.
- If there is a potential for carbon monoxide (CO) emissions, evaluators should wear a CO sensor set to alarm when CO levels get too high. If the sensor alarms, the evaluator should evacuate the building, and notify the fire department, utility, or authorized representative immediately.
- There may be an electrocution hazard if faulty wiring or electrical equipment has gotten wet.
- The evaluator should avoid contact with stagnant water and dirty surfaces, e.g., care is advised when placing down a notebook or belongings.

Table 6-2 summarizes strategies for evaluator safety with regard to environmental hazards. The first column provides a reference to the section where habitability evaluation strategies for environmental hazards were discussed in depth in Chapter 4.

Table 6-2 Evaluator Safety for Environmental Hazards

Report Section	Hazard	Safety Strategies
4.4.1	Natural gas	Do not enter if natural gas can be smelled.
4.4.2	Carbon monoxide	Carbon monoxide sensors can be worn.
4.4.3	Chemical release	Do not enter if a chemical spill or leak is suspected.
4.4.4	Soot and fumes	If outdoor air quality is diminished and or the building systems are not able to filter the incoming air, evaluators can reenter with appropriate personal protective equipment.
4.4.5	Blackwater, sewage, and mold	Assume standing water is contaminated by sewage. Avoid all contact.

Table 6-2 Evaluator Safety for Environmental Hazards (continued)

Report Section	Hazard	Safety Strategies
4.4.6	Asbestos	• If damage to material containing asbestos is suspected, do not disturb material. • If no other issues are present, evaluators can reenter with appropriate personal protection equipment.
4.4.7	Lead-based paint	If damage to lead-based paint is suspected, do not disturb material.
4.4.8	Parasites	Avoid contact with contaminated food, water, and surfaces.
4.4.9	Wild, stray, dead animals	Avoid contact.
4.4.10	Biting and stinging insects	Use protective measures to avoid contact with insects, check and remove after outdoor work.
4.4.11	Debris and refuse	Avoid walking through or standing on piles of debris and refuse.

In addition, weather conditions may affect the personal safety of evaluators in the field, or limit evaluator effectiveness:

- Flooding. Post-disaster safety evaluations cannot be completed while there is still significant standing water on property or in right-of-ways. Flood water poses drowning risk, regardless of the ability to swim. Vehicles do not provide adequate protection from flood waters, as they can be swept away or may stall in moving water. As little as six inches of water can cause loss of control of a vehicle, and two feet of water can cause it to be swept away. Additionally, wounds that become contaminated with flood waters, human or animal waste, soil, dirt, or saliva, can become infected. Floodwater is likely to be contaminated, and evaluators should avoid all contact. Flooding also proliferates water- and pest-borne illnesses.
- Rain. It is extremely difficult to perform evaluations in the rain; this is especially true if paper forms (including placards) or non-protected electronic devices are used. Wet conditions can also lead to water- and pest-borne illnesses.
- Wind. Strong winds can cause flying debris or place stresses on already damaged structures that the evaluators must walk around, as well as pose access issues. Wind may also down power lines and create electrical and fire hazards.
- Heat. Heat stroke is the most severe heat-related illness, with those afflicted showing signs of confusion, disorientation, or slurred speech. Evaluators may need to work shorter shifts, take frequent breaks, seek shade, stay hydrated with water and sport drinks, and identify any heat illness symptoms.

- Cold. It is very difficult to perform evaluations in extreme cold. Frostbite on exposed skin when handling forms or electronics is problematic.
- Snow/Ice. The hazards are similar to extreme cold but with added difficulty of reduced mobility. In addition, sliding snow and ice from structures can pose safety risks and may result in downed power lines.
- Darkness. Evaluations are best conducted during the day, as it may be dangerous to try to evaluate buildings at night. Power outages may limit work hours to periods of adequate daylight.

Best Practice

The following resources can help evaluators to prepare:

- ATC-20-1 and ATC-45 contain chapters regarding field safety for inspectors.
- Cal OES SAP *Evaluator Training* (2016a) Chapter 6 on *Field Safety.*
- The National Institute of Environmental Health Sciences (NIEHS) *Worker Training Program Disaster Preparedness and Response*: https://tools.niehs.nih.gov/wetp/index.cfm?id=556
- Earthquake Engineering Research Institute (EERI) *Field Guide Appendix B – Pre-Departure Checklist*: https://www.eeri.org/projects/learning-from-earthquakes-lfe/post-earthquake-investigation-field-guide/
- National Institute for Occupational Safety and Health (NIOSH) *Emergency Response Resources*: https://www.cdc.gov/niosh/emres/default.html
- Occupational Safety and Health Administration (OSHA) *Emergency Preparedness and Response*: https://www.osha.gov/SLTC/emergencypreparedness/index.html
- OSHA *Building Assessment, Restoration, and Demolition Assessment, Cleanup, and Repair of Structures*: https://www.osha.gov/SLTC/etools/hurricane/repair.html
- Centers for Disease Control *Health Information for Disaster Relief Volunteers*: https://www.cdc.gov/disasters/volunteers.html

6.3.3 Field Tools and Resources for Evaluators

In addition to the list of personal protective equipment listed in Section 6.2.1, evaluators should carry the following items as recommended by and adapted from ATC-20-1:

- Personal identification/driver's license
- Official identification
- Clipboard/notebook
- Pens/pencils
- Flashlight
- Cell phone/portable radio
- Digital camera
- Street maps
- Inspection forms
- Posting placards
- Yellow "caution" tape
- Staple gun/thumbtacks or tape for placards
- Emergency phone numbers
- Rain gear
- ATC-20-1 and ATC-45 *Field Manuals*
- Informational handouts
- Level and tape measure

Best Practice

The list above as adapted from ATC-20-1 Table C-2 should be used and supplemented for local conditions.

6.4 Evaluation Prioritization

In some cases, safety evaluation of critical facilities, such as those that house emergency operations centers (EOC), fire department, and police department may need to occur simultaneously with other initial response and search and rescue activities. After receiving direction from government officials and incident command, the Post-disaster Building Safety Evaluation Strike Team Leader may want to consider creating specific task forces for targeted safety evaluations. ATC-20-1 recommends conducting safety evaluations first for hospitals, police and fire stations, and EOCs. As noted in Lizundia et al. (2017), in responding to the 2010-2011 Canterbury Earthquake Sequence, officials added grocery stores, hardware stores, and pharmacies to the list of high priority inspections. Similar recommendations are in Section 2.2.9 of the California Governor's Office of Emergency Services (Cal OES) Safety

Assessment Program (SAP) *Coordinator Manual* (Cal OES, 2016b). By initially focusing selected resources to pursue evaluations of targeted community elements, officials were able to move more rapidly to open up, or deem unsafe, entire segments of the community. This approach can have advantages over the block-by-block method used in other places. However, if the buildings in the targeted groups are widely dispersed, this may reduce the number of sites a team can visit in a day, due to the travel time between sites. Local officials will direct all jurisdictional staff and volunteer responders utilizing specific training or expertise to effectively evaluate structures based on prioritization. Local officials may desire to establish a specific team to evaluate buildings with questionable damage where Detailed Evaluations are recommended as posted on the placard.

Interim Recommendation

Until detailed deployment prioritization guidance is developed, this report provides interim recommendations on issues that should be considered.

Additional Discussion and Needs

Targeted building safety evaluation teams should be created to focus on buildings needed for immediate recovery including essential facilities, such as hospitals, police stations, fire stations, and emergency operations, but also other important buildings, such as grocery stores, pharmacies, and home improvement stores. See Section 2.2.9 of the Cal OES SAP *Coordinator Manual* (Cal OES, 2016b) for additional information.

6.5 Deployment Resources

The Post-disaster Building Safety Evaluation Strike Team Leader will determine the resources needed to complete safety evaluations in a timely manner with the following considerations:

- The number of teams necessary to complete safety evaluations within the desired time frame. As a rough estimate, Rapid Evaluations average about 30 minutes, including time to write-up the evaluation and post the placard. Assuming buildings are evaluated within the same general neighborhood, a single team can perform around 10-12 evaluations in an 8-hour day.
- The number of jurisdictional staff members that can be dedicated to safety evaluation.

For additional information, the local official may want to contact local chapters of International Code Council (ICC), National Council of Structural Engineers Associations (NCSEA), or American Institute of Architects (AIA) to get an estimate of the number of buildings that can be evaluated in a single day. These organizations have experience and can assist in calculating workloads for damage evaluation teams based on damage and building density. In addition, these organizations can help determine qualifications needed to properly evaluate specific types of buildings, such as utility plants, high rise, or unreinforced masonry buildings.

6.5.1 National Level

There are several approaches to the identification of resources and their deployment should an incident rise to the level of necessitating a regional multi-state or national level response. The first step is for a state to request aid through the Emergency Management Assistance Compact (EMAC), described in Chapter 5.

In addition, the following national organizations offer solutions to contacting and requesting qualified evaluation personnel:

- Disaster Response Alliance[2] of the National Council of Structural Engineers Associations (NCSEA) and International Code Council (ICC):
    - A nationwide roster of volunteers willing to assist with response and recovery activities, including post-disaster safety evaluations, building damage evaluations, inspections, and other code-related functions in the aftermath of a disaster. All listed volunteers have completed the two-day, in-person When Disaster Strikes Institute training offered by ICC.
    - Searchable database to locate volunteers near disaster area and with specific qualifications.
- The American Institute of Architects (AIA)—Disaster Assistance Program:
    - The AIA State Coordinator Network can dispatch trained volunteers when requested by local authority in those states where Good Samaritan and workers' compensation issues have been adequately addressed.
    - All volunteers have SAP certifications from Cal OES as a minimum and have access to resilience training that places disaster evaluation response within the framework of resilient design and hazard mitigation.

[2] www.disasterresponse.org

Best Practice

Nationwide programs are useful in large-scale incidents where more evaluators are needed to complete post-disaster safety evaluation in a timely manner. However, logistics of travel and housing for out-of-town evaluators can burden local officials. ICC and AIA have established programs to match members that have available housing near an impacted area with evaluators. Additionally, nationwide databases may have experts in specific disciplines that may not be available at the state or local level. These could cover geotechnical, specific structural, or even environmental hazard experiences needed following a disaster.

6.5.2 State Level

Some states have proactively developed in-state programs for disaster response and evaluation protocols. These programs have proven to significantly expedite response times and complete post-disaster safety evaluation with minimal impact to local officials, by using nationally recognized standardized forms and evaluation techniques. Building officials associations can also serve as a resource for follow-up or continued support through recovery and reconstruction, if mutual agreements are in place. Additionally, the state associations of building officials will know when to leverage the nationwide programs as they will have firsthand knowledge of size and scope of disaster.

Training and certification requirements vary by state. Training offered by different organizations is covered in Section 5.4. The following is a list of example state-level programs:

- California
    - Trained volunteer building officials, engineers, architects and other design professionals can be deployed through Cal OES SAP[3] and the California Building Officials Association[4] (CALBO) throughout the state to respond to disasters.
- Colorado
    - The Colorado Chapter of ICC[5] maintains a database of volunteer government employees, architects and engineers that are trained to perform post-disaster safety evaluation.

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[3] https://www.caloes.ca.gov/cal-oes-divisions/recovery/disaster-mitigation-technical-support/technical-assistance/safety-assessment-program

[4] https://www.calbo.org/emergency-preparedness-response-recovery

[5] https://coloradochaptericc.org/

    - State of Colorado indemnifies specific liabilities for volunteer responders.
    - Local jurisdictions do not need to enter into formal agreement to activate responders.
- Indiana
    - The Indiana Building Emergency Assessment and Monitoring[6] (I-BEAM) Team consists of trained and qualified volunteer engineers, architects and other qualified personnel working under a cadre of state employees from the Indiana Department of Homeland Security Division of Fire and Building Safety.
    - I-BEAM has volunteer deployment command and control capabilities that can be deployed out-of-state. These capabilities including issuing badges to volunteers, providing mobile briefing and deployment management facilities, and use of heated/cooled inflatable structures to support operations, administration, logistics, medical/first aid, briefings, eating, and sleeping. The team has ability to self-support deployment for up to seven days before resupply is needed.
- New York
    - The Code Enforcement Disaster Assistance Response Program[7] (CEDAR) program provides requesting communities with post-disaster assistance as part of the statewide coordinated effort under the leadership of the Office of Emergency Management in the State Division of Homeland Security and Emergency Services. The program's initial disaster response focuses on performing Rapid Evaluation of damaged structures in affected communities.
    - Volunteers participating in CEDAR are: Certified Code Enforcement Officials; Certified Building Safety Inspectors; Registered Design Professionals; and others with specialized skills, knowledge, or abilities.
- Missouri
    - The Missouri Structural Assessment and Visual Evaluation[8] (SAVE) Coalition is a group of volunteer engineers, architects, building inspectors and other trained professionals that assists the Missouri State Emergency Management Agency with building safety evaluations.

[6] https://www.in.gov/dhs/2539.htm
[7] https://www.dos.ny.gov/dcea/cedar.html
[8] https://sema.dps.mo.gov/programs/SAVEcoalition.php

- Ohio
    - Ohio Building Officials Association[9] (OBOA) maintains a volunteer network of building officials, plans examiners, inspectors, and industry members who may provide assistance to local jurisdictions during an emergency.
- Texas
    - The Building Officials Association of Texas (BOAT) Disaster Response Team[10] (DRT) is composed of volunteer trained municipal building officials, building inspectors, architects, and engineers.
    - Architects through Texas Architects (AIA) and engineers through Structural Engineers Association of Texas (SEAoT) have memorandums of understanding that aid deployment through BOAT DRT.
    - Request for assistance must come from local jurisdictions. Requests may be filtered through State of Texas Request (STAR) managed by the Texas Department of Emergency Management.
    - State of Texas indemnifies specific liabilities for volunteers.
- Washington
    - Washington Safety Assessment Facility Evaluators[11] (WAsafe) Program assists with deployments. WAsafe is a coalition of Washington Association of Building Officials; American Society of Civil Engineers, Seattle Chapter; American Institute of Architects, Washington Council; and the Structural Engineers Association of Washington.
    - Volunteers self-register using the state's Washington State Emergency Registry of Volunteers (WAserv) web interface. WAserv maintains a database of volunteers and deploys them as requested through the Washington Emergency Management Department to help during disasters and significant events. WAsafe evaluators are called upon to evaluate both structural and building systems.
    - WAsafe resource types are described in Table 6-3.

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[9] https://www.oboa.org/web30/index.php
[10] https://boatx.org/emergency-services/
[11] https://www.wabo.org/emergency-management

Table 6-3 WAsafe Evaluator Types

Type	Duties/Limitations	Minimum Qualifications
1	Structural evaluations only: multi-family and commercial structures over 5 stories and complex structures	• Registered civil or structural engineer • WAsafe Building Safety Assessment (BSA) Evaluator; or Cal OES SAP with WAsafe-specific module
2	• Nonstructural evaluation: all multi-family and commercial structures • Structural evaluation: multi-family and commercial structures up to 5 stories	• Certified Building Plans Examiner, Commercial Building Inspector, or Building Official; or Registered Architect • WAsafe BSA Evaluator; or Cal OES SAP with WAsafe-specific module
3	Wood-framed multi-family and commercial structures up to 3 stories	• Certified Residential Building Plans Examiner or Residential Building Inspector • WAsafe BSA Evaluator; or Cal OES SAP with WAsafe-specific module
4	• Single-family residences • Accessory structures	• Any ICC Certification • WAsafe BSA Evaluator; Cal OES SAP with WAsafe-specific module; or ATC-20/45
5	As assigned by Building Official or Incident Command	• Engineers-in-Training (EITs), unlicensed architects, permit technicians, etc. with relevant experience • WAsafe BSA Evaluator; Cal OES SAP with WAsafe-specific module; or ATC-20/45

Where local officials have access to statewide programs that are recognized by state emergency management agencies, deployment of trained building safety evaluators is significantly expedited. These programs aim to deploy evaluators that are closest to the (but not directly affected by) disaster area to reduce travel time, commence safety evaluation sooner, and reduce or eliminate the need for housing or sheltering of evaluators. There is an advantage of local/regional knowledge of conditions, topography, and demographics that may need to be considered during safety evaluation. Additional advantages include knowledge of local or regional building practices and materials, as well as code requirements.

Best Practice

Many states have developed their own training and deployment protocols to meet their own needs. This may constitute a best practice for them but may not for a different state. This is especially true when differences exist in liability protection and workers' compensation coverage.

Interim Recommendation

Until detailed deployment management guidance is developed, this *Guide* provides interim recommendations on issues that could be considered depending on the incident type.

- There are organizations that maintain evaluator databases. It is recommended that volunteer data, including applicable training, experience, and expertise, be maintained in free nationwide searchable database open to local officials to search for appropriate assistance. Protocols for prioritization of resources would also need to be developed. Note that the details of such a database need to be resolved. Examples include: the security of personal data, funding of maintenance of the database and its content, validation of submitted qualifications, and aggregating the existing databases.

- Additional useful information on deployment recommendations is presented in Section 2.3 of the Cal OES SAP *Coordinator Manual* (Cal OES, 2016b).

6.6 Data Collection and Reporting

Immediately following an incident, all parties involved in response and recovery will be seeking information—EOC, local governing body, media, impacted residents, county, parish, tribal, territory, state emergency management. Each party will want similar data but in different formats.

Determining and reporting that there was a tornado, flood, earthquake, or other incident and the dates that it happened is relatively easy. Determining the number of injured, hospitalized, or fatalities is somewhat fluid, but generally can be tracked by emergency responders. On the other hand, the data that form the basis of a disaster declaration include the number of critical facilities, essential facilities, homes, apartments units, mobile homes, businesses, bridges, roads, and infrastructure that have been damaged and determining the extent of the damage. In order to engage local, state, tribal, territorial, or federal resources, it has to be demonstrated that the damage value exceeds the resource capacity of the local jurisdiction or local population. Although it is not the function of the building safety evaluator to generate a damage value, data collected during the evaluations can be used by the jurisdiction to document a total amount of damage.

Initial data collection typically starts with completing a report that summarizes the incident and estimated damage. This is commonly known as Initial Damage Assessment (IDA) and the data can be obtained from a windshield surveys or flyover of the damaged area. Through these means, impacted areas and estimated numbers of damaged structures and infrastructure can be identified. In most cases, it is desirable to obtain this information within the first 24 hours following the event.

Rapid Evaluations for buildings should be completed using a nationally recognized form such as the ATC-20-1 and ATC-45 forms; a sample is shown in Figure 6-1. Using these forms will speed data collection.

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
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: ____

____

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 6-1 ATC-20-1 Rapid Evaluation form showing types of data collected.

From these data points, the number of building types in different damage levels, such as affected, minor, major, destroyed, or inaccessible, can be compiled for different types of structures, e.g., single-family dwellings vs. critical facilities. In addition, the data will allow the estimation of total damage by building type, total damage (based on local construction costs per square foot), total number of UNSAFE, RESTRICTED USE, or INSPECTED structures, and estimated impact to taxable property value (using improvement value from local appraisal district).

Where necessary, additional questions can be added to the Rapid Evaluation forms via local amendments, such as:

- Depth of flood water in structure
- Usability categories (See Chapter 3)

Detailed Evaluations of structures and public infrastructure can commence at any time. Data collected during Detailed Evaluations can supplement or update Initial Damage Assessment (IDA) and Preliminary Damage Assessments (PDA); however, the data collection points of ATC-20-1 and ATC-45 do not completely align with those of PDA. The objectives of the PDA program are described in Section 2.4.1.

Detailed Evaluations can be suggested as part of the Rapid Evaluation or can be initiated by the property owner or local government official. The ATC-20-1 and ATC-45 Detailed Evaluation form can be used to complete these evaluations.

Data collected using either Rapid Evaluation or Detailed Evaluation forms are a vital resource for the local jurisdictions and should be managed with an understanding of the needs of the broader stakeholder community by the Post-disaster Building Safety Evaluation Strike Team Leader. The data from the safety evaluations may be used from the initial disaster declaration through recovery and reconstruction by a variety of emergency response audiences:

- Electric and water utility providers can use the information to assist in directing teams to critical or essential facilities, or to neighborhoods or businesses where structures may be habitable.
- Police or security forces can use the information to cordon off areas where damage may have caused dangerous conditions for the general public.
- Media outlets can refer to the information for reporting.
- Faith based and volunteer organizations can use the information to direct assistance to areas where their services can have the most benefit and avoid areas that are unsafe.

- Residents can use the information to understand the condition of their property.
- Building departments can track habitation of buildings and identify which buildings will need repairs, permits, and inspection.
- In the long term, planning departments can use the information to develop planning goals.

Once a disaster has been declared, state and federal assessors may deploy to the impacted area to verify reported data and collect additional data. To facilitate housing reoccupancy, additional assessors may survey the area to determine the extent of work that would be needed to make existing structures habitable, and to determine if utilities are available and/or the prospect of having utilities available.

During a Rapid Evaluation, information is captured in two principal ways: on paper forms or electronically on tablets or mobile phones. In large-scale disasters, transfer of the data from individual paper forms into a manageable format can be cumbersome and time consuming, delaying delivery of time-sensitive information to emergency management and needed damage estimation. There are a multitude of methods for capturing electronic data: they range from using proprietary software products to using editable open source and free software solutions. Electronic solutions offer the possibility of making data collection much more efficient. Additionally, some electronic data collection solutions have the ability to capture photographs of damaged structures, link directly to GIS mapping, and can also require (unlike a paper collection form) a user to complete specific data points before they can move on to the next assignment. These enhancements can have a significant impact in ensuring complete data collection as well as real time mapping of Rapid Evaluation results. However, internet connectivity or the lack thereof following an incident can impair the use of some electronic methods. Additionally, if the tool is not modeled after nationally recognized forms, data points may be missed if evaluators are not trained specifically.

Best Practice

Rapid Evaluation and Detailed Evaluation forms as presented in ATC-20-1 and ATC-45 should be used.

Interim Recommendation

- Additional data points should be added to the existing ATC-20-1 and ATC-45 forms to capture data that may be relevant to reoccupancy. Examples include depth of flood water in structures on ATC-45 and usability categories (see Chapter 3).

- Other potential modifications that have been implemented by some jurisdictions and could be considered include adding a row under "observed conditions" for exterior cladding, roofing, window, and siding damage (particularly on ATC-45 forms), and separating the "Minor/None" column into "Minor" and "None" for more accuracy and clarity.
- An electronic tool that overcomes connectivity issues and standardizes data points, including those that are required for state and federal disaster declarations, would make data collection more efficient and accurate.

6.7 Quality Assurance

Following the 2010-2011 Canterbury Earthquake Sequence in New Zealand, post-earthquake safety evaluation procedures similar to those in ATC-20-1 were used. It was found that lack of adequate training of evaluators led to overly conservative tagging and forced re-evaluations of buildings by more experienced evaluators (ATC, 2014b). In addition, experience with applying ATC-20 in past earthquakes in the United States has shown that the documented procedures are not always followed. Figure 6-2 through Figure 6-4 show examples of issues from past earthquakes in California.

It is important that Post-disaster Building Safety Evaluators are properly trained and certified as discussed in Section 5.4 and that they remain current in their evaluation skills. Cal OES, for example, provides an online refresher training course for individuals who have previously completed training.

As noted in Lizundia et al. (2017), "while post-disaster safety evaluation guidelines typically provide instruction on how to use evaluation forms and placards, they typically do not provide advice and warning regarding common mistakes or inappropriate practices. These usually occur with the RESTRICTED USE placard. Guideline updates should consider showing examples of inappropriate practices and/or provide warnings. Examples could include items such as: (1) do not leave previous placards after a new one is posted; (2) do not post different placard categories at different building entrances; (3) do not use ink that cannot survive sunlight or rain; (4) do not change the wording on the recommended forms; and (5) do not forget to check the required boxes on the RESTRICTED USE placard." Other recommendations include the need to clearly state what is being restricted on the RESTRICTED USE placard, e.g., "don't occupy [specify what part] of the building," "don't use [specify] entrance," or "entrance only permitted to recover belongings."

Figure 6-2 Placard posting approach in commercial building in 2010 Eureka, California earthquake. The initial placard was a yellow RESTRICTED USE tag with the recommendation for an engineering review. The placard was subsequently changed to a green INSPECTED tag, but still said an engineer review is required.

Figure 6-3 Placards posted on a government building in 2010 Eureka, California earthquake. Both yellow RESTRICTED USE and red UNSAFE placards were observed. Placards should be consistent on each side of the building.

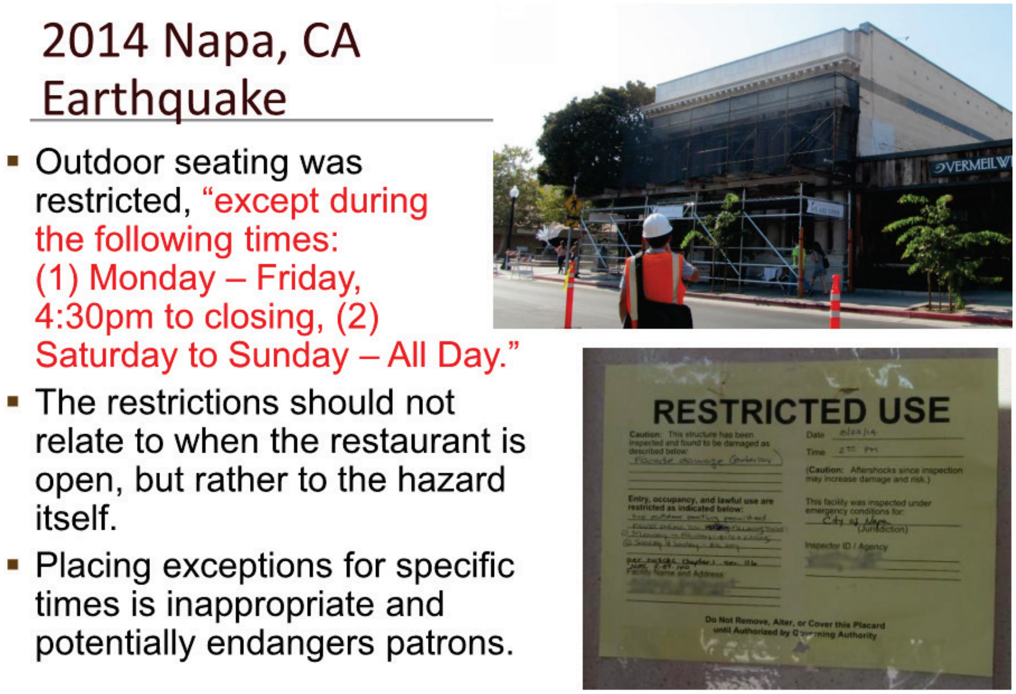

Figure 6-4 Placards posted on a commercial building in 2014 Napa, California earthquake. The restrictions on the yellow RESTRICTED USE placards should relate to the actual hazard, not to when the restaurant is open.

Improved quality is desirable as a general principle. With post-disaster building safety evaluations, the question is: What "quality" are we trying to "assure?" This can be defined as follows:

- The evaluation and the placard are consistent with the intent of the post-disaster safety evaluation standard.
- The evaluation and placard category would be generally consistent with the median evaluation of a group of experienced, trained Post-disaster Building Safety Evaluators.
- Key items that can reasonably be seen are not missed.
- Instructions on the placard are clear to a layperson.

The third edition of FEMA P-154 (FEMA, 2015a), which focuses on evaluating buildings for seismic potential hazards *before* an earthquake, introduced the concept of a "Supervising Engineer" who should be a local practicing structural engineer with a background in seismic evaluation and risk evaluations. In addition to establishing parameters of the screening process, the Supervising Engineer is available for screeners to consult with during field screening, reviews completed forms, and assists in interpreting the results of the program.

A similar approach can be applied to post-disaster safety evaluations to provide higher quality assurance and ensure more consistent evaluation results. The Post-disaster Building Safety Evaluation Strike Team Technical Supervisor, described in Section 5.3, is responsible for quality assurance in the building safety evaluation process. The Technical Supervisor's responsibilities include the following:

- Answer questions on evaluation criteria, procedures, and appropriate conclusions and language to use on placards.
- Depending on the size of the event, review a statistically meaningful sample of the received evaluation forms and compare them with the placard statistics and photos of damage to look for inconsistencies.
- Perform selected field checks to make sure the deployed evaluators are performing appropriately.
- Oversee the data collection process and spot checking.
- Help decide on when to perform Detailed Evaluations.
- Determine trends that are common among the different evaluators and provide guidance to evaluators on specific items to watch for.
- Advise on upcoming deployments.
- In some situations, it may be beneficial for the Technical Supervisor to communicate with Evaluators in the field in real time, allowing them to view buildings through remote camera feeds (e.g., to assist in consultation).
- The Technical Supervisor will also discuss any local modifications to post-disaster evaluator forms with Evaluators before they begin field evaluations. Examples were discussed in Section 6.6.

Interim Recommendation

Personnel in the post-disaster evaluation teams should include a Technical Supervisor with responsibility for quality assurance. The Technical Supervisor works under the direction of the AHJ and the Post-disaster Building Safety Evaluation Strike Team Leader.

Additional Discussion and Needs

- More detailed quality assurance guidelines should be developed.
- Post-disaster evaluation guidelines, such as ATC-20-1 and ATC-45 should be updated to show examples of inappropriate practices and/or provide warnings.

6.8 Reevaluation Triggers

In some incidents, secondary incidents may raise the question of whether a reevaluation of the initial evaluation and placard is necessary. Most natural hazard incidents have inherent secondary events that will warrant reevaluation of the affected buildings and structures. In an earthquake, there may be a significant aftershock that follows the original main shock. Flood waters may recede and then rise again. Mold growth may be exacerbated. Snow may melt and then accumulate in a subsequent storm. Secondary high wind incidents (e.g., derecho, tornado, or even normal wind patterns) may affect structures that were initially impacted by a hurricane incident.

As summarized in *ATC-20-1 Bhutan, Field Manual: Postearthquake Safety Evaluation of Buildings* (ATC, 2014a), one approach to help determine whether an aftershock has caused damage that warrants reevaluations is through the use of indicator buildings. This is also discussed briefly in Section 2.2.8 of the Cal OES SAP *Coordinator Manual* (Cal OES, 2016b) and in more detail in Section 5.9.3 of the New Zealand Ministry of Business, Innovation and Employment's *Managing Buildings in an Emergency* (MBIE, 2018). First implemented during the 2010-2011 Canterbury Earthquake Sequence in New Zealand, the concept is to select a set of representative buildings in the affected area, such as a city. The local authority monitors these buildings and reevaluates them following an aftershock. If the indicator buildings sustain new damage in the aftershock, it is recommended that other similar buildings in the affected area be reevaluated. If the indicator buildings do not sustain new damage, the local authority would not reevaluate all similar buildings. If the AHJ is notified of new damage observed in any building following an aftershock, then an evaluation should be conducted. This approach can help prevent unnecessary reevaluations. Where resources are available, strong motion instrumentation can be deployed in the indicator buildings for comparison with response recorded in other areas.

It is noted that the use of indicator buildings requires the accurate identification of appropriate building stock. Due to the broad array of construction types, ages, geometry, in addition to variations in quality of construction, the use of indicator buildings requires that the AHJ take a conservative approach to identifying and selecting the comparative buildings. Variation in local geology may also be an important consideration that can impact the level of shaking. Further, the use of this system may not always be possible due to the extensive variation in building type, age, geometry, foundation materials, and site preparation.

Another type of trigger for reevaluation is when a damaged neighboring building was the cause for the RESTRICTED USE or UNSAFE placard, and the neighboring hazard has been mitigated. For example, a rock fall hazard may have been removed, or a leaning building that threatened to fall on its neighbor may have been stabilized.

Interim Recommendation

The concept of indicator buildings should be implemented as part of U.S. practice to help determine which buildings need reevaluation after aftershocks. In the near term, this can be done on a case-specific basis in the affected community using the resources available, using the resources available in Cal OES (2016b) and MBIE (2018).

Additional Discussion and Needs

- Detailed guidance for the use of indicator buildings in earthquakes should be developed.
- Guidance should be developed for reevaluation triggers for other incident types. This might include selective flyovers for floods or selective drone deployment.
- In the longer term, increased building strong motion instrumentation over a geographically dispersed region and in a wide range of building types is recommended to avoid the difficulty of deploying instruments following a disaster.

6.9 Changing or Removing a Placard

A posting category can change following an earthquake aftershock or other subsequent incident if reevaluation confirms that damage is more severe, and an INSPECTED placard should change to a RESTRICTED USE or a RESTRICTED USE placard should change to UNSAFE. However, it is more common for a placard to be changed from a RESTRICTED USE placard following a Rapid Evaluation to either an INSPECTED or an UNSAFE placard during a reevaluation, such as when a Detailed Evaluation follows an initial Rapid Evaluation. Conditions may have changed, or a more detailed review may permit a more refined evaluation. However, placards contained in ATC-20-1 and ATC-45 include the statement "Do Not Remove, Alter, or Cover this Placard until Authorized by Governing Authority." Thus, in order to change or remove a placard based on subsequent evaluations, the AHJ needs to grant authority. In some jurisdictions, evaluators who have been trained and have certifications are deputized by the jurisdiction to conduct the evaluation or reevaluation and thus have authority to update placards. In other jurisdictions, government employees are partnered with volunteer evaluators, and government employees sign the placards and thus would be needed to change or remove a placard.

The City and County of San Francisco has a Building Occupancy Resumption Program[12] (BORP) to utilize private engineers to improve the effectiveness of post-disaster safety evaluations. Under this program, a pre-event evaluation plan is developed for a building and approved by the City, and engineers are pre-qualified and deputized to perform building safety evaluations. A few other cities have adopted similar programs, including Salt Lake City (Salt Lake City Corporation, 2014).

Regardless of who has authority to modify a placard, the underlying question is what criteria govern modifications. ATC-20-1 and ATC-45 focus on the evaluation itself, not on what is needed to change the evaluation. ATC-20-1 notes, "Any change in posting category (i.e., reposting) must be done only by an authorized representative of the local building department." On the face of it, the presumption would be that repair, strengthening, or removal of the condition that led to a RESTRICTED USE or UNSAFE placard would be needed, but in practice this can be a nuanced and challenging situation. Is repair to the pre-existing condition sufficient, even if that condition was not compliant with current code? Some jurisdictions have implemented policies regarding the level of repair and strengthening that is needed. The *International Existing Building Code* sets forth requirements, but it does not directly link to ATC-20-1 or ATC-45. *Understanding Substantial Structural Damage in the International Existing Building Code* (FEMA, 2017) is an informative document.

Interim Recommendation

On a case-by-case basis, the AHJ will need to set policies for what is required to change or remove a placard.

Additional Discussion and Needs

In the longer term, consensus and explicit guidance is needed to address the following questions:

- Who has authority to reevaluate and change a posted placard?
- Can a qualified private engineer or architect change a posted placard? Should the community have a BORP policy that includes this?
- As risk of aftershock or other secondary event risk diminishes, are there situations where placard type or restrictions can be relaxed?

[12] https://sfdbi.org/borp

- What information is needed change a posting from UNSAFE to RESTRICTED USE or from RESTRICTED USE to INSPECTED?
- After a flood, there may be situations where blackwater and contaminants have been removed and repairs have been completed by qualified contractors; or where electrical components have been replaced by certified electricians. In these or similar scenarios, the AHJ may allow a certified contractor to change or remove the placard. This was done following flooding in British Columbia in 2012 (Bibby, 2019).

6.10 Cordoning and Barricading

As discussed in Section 2.5, code officials have the authority to close sidewalks and streets adjacent to unsafe buildings. Cordoning and barricading of buildings were discussed in FEMA P-1024, *Performance of Buildings and Nonstructural Components in the 2014 South Napa Earthquake* (FEMA, 2015b). The following text is verbatim from FEMA P-1024, and though this was an earthquake, the observations can apply to buildings damaged by other types of disasters.

> *ATC-20-1, Field Manual: Postearthquake Safety Evaluation of Buildings, (ATC, 2005) provides limited guidance on barricades but does not provide details of design and location of barricades and fencing. Following review of the 2010 and 2011 earthquakes in Christchurch, New Zealand, the development of guidelines for barricades and cordons was identified as a high priority. As a result, the volunteer members of CALBO developed the Interim Guidance for Barricading, Cordoning, Emergency Evaluation and Stabilization of Buildings with Substantial Damage in Disasters (CALBO, 2013). The Guidelines note that requirements in California Building Code Chapter 33, Safeguards During Construction, apply only to stable buildings under construction and not unstable, damaged buildings. Other code language, though, provides the authority to close sidewalks and streets adjacent to unsafe buildings (see Section 2.3). The Guidelines recommend initial placement of soft barriers, such as fencing, at horizontal distances (H) up to 1.5 times the height (V) of the façade or structure at risk, termed a 1.5H:1V setback, "to allow for the possibility that falling items can bounce and shatter." Wide safe distances including block-long cordons are warranted until inspectors, SAP evaluators, building owners, engineers, contractors, and other agents can evaluate, stabilize, or remove potential falling or collapse risks and erect hard, impact resistant barriers to protect the public.*

Best Practice

The Interim Guidance for Barricading, Cordoning, Emergency Evaluation and Stabilization of Buildings with Substantial Damage in Disasters (CALBO, 2013) can be used to make decisions about barricading, cordoning and emergency stabilization.

Additional Discussion and Needs

FEMA P-1024 also provides a set of recommendations that are repeated here verbatim.

- *The effectiveness of scaffolding and other types of barricades in providing life safety protection against various types of falling hazards is not well understood. A research project is recommended to compare the effectiveness of various forms of scaffolding and barricading against different falling hazards. This could include smaller and larger masonry elements from different heights. Guidance should be provided to assist engineers with design of barriers to protect against damage posed by falling masonry.*
- *Further development of consensus guidelines, such as the Interim Guidance for Barricading, Cordoning, Emergency Evaluation and Stabilization of Buildings with Substantial Damage in Disasters (CALBO, 2013) into a formal document is recommended and should involve various stakeholders and professionals with relevant expertise. This work should include discussion about protection not just of the public way, but also adjacent buildings in potential danger from damaged structures. It should consider guidance from Appendix 5 "Cordons and Barricades" from New Zealand's Managing Buildings in an Emergency* (MBIE, 2018).
- *The local AHJ should establish criteria for the placement of barricades and fencing around damaged buildings that allows for some flexibility based on easily identifiable conditions. This would establish baseline requirements that could be followed consistently following an earthquake.*
- *Where occupancy is granted for a structure that has damaged elements posing as falling hazards, there should be follow-up site visits by the local building or fire authorities to confirm that limited access and barricading requirements are being followed.*

In addition, data could be collected from cities that frequently use barricades, such as New York City, that make extensive use of sidewalk sheds, to gather information about their effectiveness.

6.11 Communication with the Public, the Media, and Building Owners and Occupants

In our connected, data-driven world, the public and media expectations for instant and accurate information are high and information is expected to be communicated in many formats suitable for many audiences. Messages must be accurate and consistent. To ensure that, standard operating procedures are adopted by many jurisdictions. These procedures often include:

- Unified command. Unified message. Unified delivery.
- There should be a single point of contact for all governmental agencies under a joint information center.
- Information should be limited to verifiable facts.
- Information should be attributable to government officials or other official sources.
- If information is not available or spokesperson does not know, identify information requested and get back to requestor.

In addition, the public, both in and outside the emergency area, need direct links to data and information. Accordingly, information needs to be provided on-line in various social media platforms and through mobile phone and other hardware means, as well as in the more traditional forms of radio and television. Close to real-time updates of data are expected, particularly with regard to individual structure conditions, such as "placarding status." Clear policies directing social media interaction and distribution of information are critical.

In addition to words and text, the public expects data in other digital and analog forms—maps, lists, overlays, graphic summaries. Provision of extensive information and data, perhaps even before it may have been fully analyzed and edited, is necessary to meet public expectations and instill confidence in response and recovery activities. Many, perhaps most, Americans consider mobile phone service and digital connectivity to be essential to their daily lives. There should be a focus on meeting these digital communications needs.

As previously discussed in Chapter 3, it is critical to communicate the meaning of the placards to the public. What does a "red," "yellow," or "green" placard mean to users regarding entry, use, and habitability? How soon must various actions be taken? Are there occupancy or other restrictions in or around designated areas? Standardized templates for these common questions should be developed.

Providing further sources of information and assistance is one of the primary needs in the emergency period. Emergency notification systems used by many municipalities are a method of facilitating the one-way dissemination or broadcast of messages to people linked to the system. The systems can be scalable and can target specific groups or localized areas for information dissemination. Use of this technology could drastically improve the ability to communicate directly with people affected by a disaster and target specific information dissemination based on damage. Such one-way communications cannot receive specific information or address questions by recipients. A high level of staffing on various platforms, such as social media, telephone, and others, would be needed to provide truly interactive communications. Such staffing demands could be reduced to some extent by using models provided in many other industries in which artificial intelligence can respond to specific questions with custom-tailored information.

Interim Recommendation

It is recommended that AHJs develop standard operating procedures for communication following incidents.

Chapter 7

Emerging Technologies and Development Needs

7.1 Overview

The previous chapters presented best practices, interim recommendations, resources, and additional discussions on building safety and habitability evaluation and management of these practices. This chapter presents future research and development needs and emerging technologies that are on the horizon.

7.2 Building Owner's Guide to Safety Assessment

In a significant incident, many thousands of structures may be within impacted areas. Responding post-disaster building safety evaluators will most likely initiate their work in areas where damage is most severe, delaying determinations of some structures by post-disaster building safety evaluators for days or weeks. In this time period, occupants may be reluctant to enter buildings until an evaluation has been conducted and a placard has been posted. Whereas conditions, such as minor plaster cracks in walls of a wood-frame dwelling, may appear to indicate imminent structural failure to the untrained person, a structure with this type of minor, nonstructural damage has not lost its structural integrity, and may be reoccupied. Restoration of occupancy in such structures can assist in reducing human stresses, reduce demand for shelter and other services, and generally benefit immediate recovery operations.

It is recommended that a simplified guide to safety assessment by building owners or their representatives be developed to assist in providing confidence that a building may be occupied, or, conversely, that damage requires a more detailed assessment by a trained inspector/evaluator. Such a guide would allow a cursory review of the building by nontechnical persons, following a checklist of basic hazards. As an example, the following is a list of items that may indicate that entry to a structure following an earthquake should be limited until a building safety evaluator posts the building:

- Noticeable tilt or lean based on a clear method of measurement
- Collapse or partial collapse of any element

- Evidence of smoke or fire is present (in this case, request immediate assistance)
- Over half of windows are broken
- Cracks in exterior walls allow view through to structure interior

At the time of writing of this *Guide*, the California Earthquake Authority (CEA) was completing the development of CEA-EDA-01, *Earthquake Damage Assessment and Repair Guidelines for Residential Wood-Frame Buildings, Volume 1 – General*, that summarizes the process and details of assessment and repair of common types of earthquake damage in typical residential wood-frame buildings by homeowners with a good understanding of home construction and repair, contractors, and insurance claim representatives (adjusters). Although the CEA document addresses only the building components that are typically found in single-family wood-frame dwellings, it can also apply to small, multi-family dwellings that use similar components.

Recommendations

A simple, short guide for safety assessment of damaged buildings by owners or their representatives could be developed for distribution, along with relevant training materials by building departments and other organizations. The development of the guide should include review by knowledgeable evaluators, interested owners and lay persons, and legal advisors. It may be necessary to have separate documents for different types and sizes of buildings, as each guide should represent the needs and expectations of impacted jurisdictions. Guides should address common incident types beyond earthquake as well.

7.3 Emerging Technologies

While response to an emergency may start with no more than a notebook and pen, as emergency response and recovery efforts get organized, more advanced technologies can be incorporated. This section discusses some current and emerging technological support programs. Many are not yet fully available for use in emergency circumstances, but ongoing research and development may allow them to be applicable soon. Technical support can assist responders to meet the ever more technologically sophisticated planning, response, and general community needs.

Expert assistance is required for the application of many emerging technologies. Developing such contacts and, even, contracting for services in advance for such assistance is necessary.

7.3.1 Social Media

Social media has become ubiquitous for data collection and sharing and provides an invaluable opportunity for sourcing widely distributed data through crowdsourcing. Social media sites can add to emergency management efforts, filling gaps or confirming information on damage and impacts, coordinating with aerial and satellite imagery, understanding public needs and mood to inform decision-making by the Post-disaster Building Safety Evaluation Strike Team Leader. At this time, these data analysis tools require significant levels of highly trained staff. Future years can be expected to provide greater automated integration of data from multiple sources to provide whatever information is required.

Another use of social media in our "sharing" culture may be to connect affected persons with other members of their communities to find temporary housing, transport, or other needed assistance. Social media also provides a primary means of communicating between jurisdictions and the public.

7.3.2 Machine Learning and Artificial Intelligence

Machine learning and artificial intelligence applications are currently under development to extract information from large numbers of photographs or videos in order to benefit structural safety evaluations. For example, an ongoing project at Purdue University has developed a system for automatically classifying images of building components into categories, such as collapsed, not collapsed, or affected by spalling (NHERI, 2018). Such a system can be utilized to classify images showing specific types of damage to buildings, as well as to quickly identify areas of a city with higher concentrations of damage to help prioritize deployment of evaluation resources.

Machine learning and artificial intelligence for structural safety evaluation requires complex data and pattern analysis, predictions of human behavior, and other technical and social analysis. The likely flood of information will need to be carefully reviewed by emergency managers and other trained professionals to extract meaningful patterns and details, to be efficiently field verified for accuracy, and to have data be useful in direct operational activities.

7.3.3 Strong-motion Data

Great advances in miniaturization of self-powered, remote strong-motion data collection devices are currently being made, presaging low cost and widespread future instrumentation of structures, both new and existing. The data collected from accelerometers that have already been placed in many structures, particularly tall buildings and structures of "special design," could allow engineers to gain an understanding of individual structure performance. Data can be used, for example, to determine if a tall building approached or exceeded its theoretical elastic drift limits, which might indicate that additional inspection of structural elements is warranted. Issues related to use and release of proprietary data remain problematic. Such data will be valuable in validating and calibrating engineering design methodologies.

Accelerometers in mobile phones also present a big potential opportunity for collection of distributed information about earthquake shaking. Initial projects, such as University of California Berkeley's MyShake[1] program, to build networks of strong motion instrumentation based on real-time data sent from the smartphones of volunteers, are underway.

Strong-motion data from individual structures might be also useful when aggregated to provide emergency response managers with more detailed information on localized shaking and expected general building performance, supplementing current data collection and predictive modelling.

7.3.4 Geospatial Data

Emergency response and safety evaluation activities are supported by data, such as identification of personnel needs and deployment strategies. The ongoing demands for data collection and visualization are spurring enhancements in developing presentation models, such as those using geo-location to create three-dimensional modeling. Data now also include capabilities of time sequencing, georeferencing, information integration, and incorporation of expert notes.

Satellite data collection and imaging is currently available, and it has been shown to be a valuable technology for emergencies that extend over larger areas.

The U.S. Geological Survey's Emergency Operations Office, through their Hazard Data Distribution System[2] (HDDS), coordinates and supports the collection and utilization of imagery from various agencies and groups. These data can track and map impacts, such as water, hail, fire, structure damage, movement of people and animals, allowing emergency managers and assessment personnel to better understand conditions in an area that may otherwise be obscured or difficult to access. Geospatial information is available from other agencies worldwide, and various private firms sell or

[1] http://earthquakes.berkeley.edu/myquake/
[2] https://www.usgs.gov/land-resources/hdds

license services to provide such information. The USGS provides training for their national map products and services[3].

One particular benefit to geospatial data collection is identifying building locations that may be missing addresses or other signage. To overcome this, communities could consider assigning a unique identifier, e.g., place ID[4]. An identifier could be assigned to each building footprint, which would result in a building and its location being associated with that unique identifier that can be shared across all disaster operations and various building assessments. This will not only help identify buildings that may need to be located for immediate or urgent needs, it will also be a helpful identifier for the results of each assessment team that can then be used to revisit the building if needed, or as data that can be shared with other post-disaster field assessment activities to help prioritize their field activities. This could potentially provide emergency managers improved situational awareness to prioritize resources and reduce the number of post-disaster damage assessments if teams collaborate and share data on a common platform.

The U.S. National Grid[5] (USNG) is an effort to solve the issue of locating structures when street addresses may not be available. USNG is an alpha-numeric point reference system that has been overlaid on the Universal Transverse Mercator (UTM) numerical grid. Every modest size home in a discrete area can be described using 8-digits (e.g., 1234 5678). By adding a two-letter prefix (e.g., XX 1234 5678), the location is identified regionally (statewide).

Another example of a unique identifier might be the use of the mobile application what3words[6] that divides the world into a grid of 3-meter by 3-meter squares and assigned each one a unique 3-word address.

In large-scale incidents, all responders may benefit from the establishment of a clearinghouse, which is a central location (physical or virtual) for exchanging information related to the disaster. The National Earthquake Hazards Reduction Program (NEHRP) has published *The Plan to Coordinate NEHRP Post-Earthquake Investigations* (USGS, 2014) that "puts forward a framework for both coordinating what is going to be done and identifying responsibilities for post-earthquake investigations." One of the identified activities is the establishment of a technical clearinghouse that can include the facilitation of an online data clearinghouse. An example is the series of

[3] https://www.usgs.gov/core-science-systems/national-geospatial-program/training
[4] https://developers.google.com/places/place-id
[5] https://usngcenter.org/
[6] https://what3words.com/

virtual earthquake clearinghouses facilitated by the Earthquake Engineering Research Institute[7]. Research organizations have also established data clearinghouses following disasters. As an example, after Hurricane Katrina Louisiana State University (LSU) created the LSU GIS Information Clearinghouse[8] as a central repository for geospatial data and information related to the disaster. The LSU Clearinghouse facilitated many of the data access and distribution needs of federal, state, and local efforts and served to meet the needs of the mitigation and long-term planning aspects of rebuilding Louisiana. In addition to the downloadable data available through the website, the LSU Clearinghouse stored information that is not for public release and provided secure access for appropriate agencies.

7.3.5 Aerial Vehicles

Commonly used in many jurisdictions, unmanned aerial vehicles (UAVs or drones) have a vast range of application, far broader than the general surveillance, allowing visual survey and up-close views, for which they are typically used. Through many types of specialized sensors, information can be collected, such as video documentation, or thermographic imaging sensors that can sense infrared radiation to detect warm objects such as persons and fires. Also available are capabilities for high intensity lighting (spotlights), loudspeakers, geo-referenced surveying and 3D mapping, detailed measurements, deliveries of medical supplies and other goods, communications with ground-based personnel, real-time security monitoring, and relay points for wireless and other information-gathering and communications services. Drones can enter dangerous or contaminated areas. Managers and technicians can watch video and data feeds from drones in real-time.

Current Federal Aviation Administration standards (FAA, 2018) limit UAVs to 55 pounds, including vehicle and payload, and require that the vehicle be operated at a maximum altitude of 400 feet within eyesight of a certified “remote pilot in command” operator. The regulatory environment and piloting technology for drones is rapidly changing, requiring response and assessment managers to maintain a constant view of this emerging technology.

7.3.6 Other Technologies and Applications

Other technologies of use in emergency management and safety evaluations are being developed or on the horizon for management, response, and public interaction, including:

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[7] http://www.eqclearinghouse.org/
[8] https://prrac.org/pdf/Katrina-LSU-GIS.pdf

- Use of virtual and enhanced reality
- Development of mobility enhancements
- Development of remote operational tools
- Integration of data sources
- Aftershock calculation tools, including estimation of residual capacity (observable damage vs. remaining strength)
- Standardized methodologies for information compilation and analysis, presentation to many audiences
- Use of geographic information system (GIS) data to estimate impact of an impending incident, such as a tornado

Recommendations

There is a need for jurisdictions to keep current on advances in technology that will impact their operations and to prepare for implementation as the advances become available. Some suggestions include:

- Assignment of persons or agencies to review literature on a periodic basis and provide summaries of important developing technologies.
- Assignment of UAV service planning and operation to staff or to contract providers. Jurisdictions should develop overall policies under which all agencies might follow the same regulations and guidance, with the ability to share resources.

Chapter 8

Conclusions and Recommendations

8.1 *Guide* Overview

This *Guide* was developed as required by Section 1241(a) of the *Disaster Recovery Reform Act* (DRRA) of 2018 and begins with a review and definition of post-disaster building evaluations and discusses other types of assessments that often occur following an incident. The *Guide* then summarizes issues related to structural integrity (termed structural safety herein to more clearly identify the goal) and livability (termed habitability herein to more broadly cover not just residences but other occupancies like commercial and retail). This is followed by guidance on program planning prior to an incident and program management and implementation practices after an incident.

It is not the intent of this document to establish FEMA or federal policy. Rather, this *Guide* summarizes and references current best practice guideline documents. In some cases, potential improvements to these documents or issues to be investigated are identified. For some incident types or issues, guidance documents have not yet been developed or standardized. In such cases, interim recommendations are provided in addition to identification of needs to fill these gaps to help serve as a road map for future efforts by the disaster response community.

Section 8.2 summarizes the key conclusions of the *Guide*. The remaining sections compile best practices, where available, and interim recommendations identified in Chapters 3 through 6 by target audiences for this *Guide* as defined in Chapter 1 by:

- Primary: Architects, engineers, and building officials directly involved in post-disaster building safety evaluation
- Secondary: Emergency managers and health officials who may be involved in management of the post-disaster evaluation process, including environmental health issues
- Tertiary: Policy makers at state, local, tribal, and territorial (SLTT) and federal government levels

Available best practice guidance is identified below for each audience. While clear best practice guidance exists for some issues, some issues are currently covered by interim guidance that, in the absence of development time, can also be implemented immediately. Discussion of recommended improvements, needs, and issues is typically not provided in this executive summary in the interest of brevity, but it is provided in Chapters 3 through 6.

8.2 Key Conclusions

Key conclusions of the *Guide* are as follows:

- Current post-disaster building safety evaluation guidelines for wind, flood, and earthquake incidents have a proven track record of success in past incidents. Only minor refinements are recommended.
- Best practice guidelines are needed for other incident types, including: tornadoes; tsunamis; landslides and other land instabilities; volcanoes; snow, hail, and ice storms; fire; and explosions. The *Guide* provides interim recommendations and advice on what should be developed in the future.
- Past incidents have clearly demonstrated that in order for evaluation programs to work effectively, proper planning, management, and implementation are essential. Before the incident, this includes training and certifying evaluators and evaluator supervisors to properly perform evaluations, training building officials and emergency managers in managing the evaluation process, developing appropriate emergency management plans, and making sure mutual aid resource agreements are in place and understood so they can be utilized when the incident exceeds local capacity. After the incident, this includes deployment safety, management, and prioritization of appropriate evaluators for the incident type and scale; effective collection and reporting of the data developed during the evaluation process such as placard posting status and rationale; and quality assurance oversight of field evaluators by experienced and technically qualified individuals. Effective post-incident management also includes policies on reevaluation triggers for follow-on events, such as earthquake aftershocks; policies on how placards can be changed or removed; proper procedures for cordoning and barricading damaged buildings; and effective strategies for communicating with the public, media, and building owners.
- In many local jurisdictions across the United States, laws and policies are needed to properly implement post-disaster evaluations, including Good Samaritan Laws to protect volunteer evaluators, and legislation to create

the authority to evaluate and post buildings, deputize evaluators, restrict occupancy, and demolish buildings.

- The focus in the past for post-disaster evaluations has been on structural safety. However, even if the structure of a building has not been significantly damaged, the ability to reoccupy the building may be compromised by nonstructural damage, environmental hazards, or a lack of necessary services such as fire protection, plumbing, or elevators. The *Guide* provides a detailed discussion of pre-disaster habitability requirements and how they apply and are evaluated following an incident. The concept of permitting temporary, reduced standards for selected building services and systems until full repairs can be made is reviewed; issues and questions for communities to address are provided; and potential policy approaches are described.

8.3 Best Practices for Post-disaster Building Safety Evaluators

Building safety can be impacted by different incident types. While well-established post-disaster safety evaluation guidelines are available for earthquake, windstorms, and flood events, no specific guidance is available for other incident types, such as tornadoes, tsunamis, landslides and other land instabilities, volcanoes; snow, hail, ice storms, fire, and explosion events.

Following an *earthquake* event, current best practice is the use of the second edition of the ATC-20-1, *Field Manual: Procedures for Postearthquake Safety Evaluation of Buildings*, (ATC, 2005). ATC-20-1 is used for what are termed "Rapid Evaluations" and "Detailed Evaluations." More detailed "Engineering Evaluation" guidance is available for selected building types including FEMA 306, *Evaluation of Earthquake-Damaged Concrete and Masonry Wall Buildings: Basic Procedures*, (FEMA, 1998) and FEMA 352, *Recommended Postearthquake Evaluation and Repair Criteria for Welded Steel Moment-Frame Buildings* (FEMA, 2000).

Following a *windstorm* or *flood* event, current best practice is the use of the first edition of the ATC-45, *Field Manual: Safety Evaluation of Buildings after Windstorms and Floods*, (ATC, 2004) for evaluating damage.

Following a landslide or other *land instability* event, current best practice is the use of the *Field Guide: Rapid Post Disaster Building Usability Assessment – Geotechnical Assessment* (MBIE, 2017) for evaluating damage.

Following a *volcano* event, currently no best practice guideline exists that specifically addresses evaluating damage caused by this incident type. Such a guide should be developed. In the interim, ATC-20-1 is recommended for use in evaluating structural safety from damage caused by volcanoes that is similar to earthquake loading, including ground shaking induced by the volcano, explosive damage from volcanic blasts, damage to roofs from the weight of ash and projectiles, and reduced capacity from structural elements exposed to fire and heat from lava. ATC-45 is recommended for use in evaluating damage from mudflows (lahars) and flooding caused by melting snow.

Following a *hail* event, currently no best practice guideline exists that specifically addresses evaluating damage caused by this incident type. Such a guide should be developed. In the interim, ATC-45 and *Composition Roofs Damage Assessment Field Guide* (Haag Education, 2019) are recommended for use in building safety evaluations.

Following a *snow* or *ice storm* event, currently no best practice guideline exists that specifically addresses evaluating damage caused by this incident type. Such a guide should be developed. In the interim, ATC-20-1 is recommended for use primarily from a roof structural safety perspective.

Following a *fire* event, currently no best practice guideline exists that specifically addresses evaluating damage caused by this incident type. Such a guide should be developed. In the interim, ATC-20-1 is recommended for identification of structural deformation when initial triage and evaluations commence. If the building is leaning because of compromised components from the fire damage, the ATC-20-1 criteria can be applied in a fairly straightforward manner. Further discussion regarding the loss of lateral force-resisting and gravity load-carrying capacity from fire damage is provided in Section 3.8.

Following an *explosion* event, currently no best practice guideline exists that specifically addresses evaluating damage caused by this incident type. Such a guide should be developed. In the interim, the ATC-45 Detailed Evaluation checklist methodology presents the most appropriate criteria for most post-blast safety evaluations.

Most incidents are inherently complex with widespread impacts to communities, infrastructure, the natural environment, and society. The complexity increases when the initial event is followed by a related and yet unique incident which, in and of itself, generates a different type of damage. Currently, no best practice guideline exists that specifically addresses building safety evaluations following *multi-hazard* incidents. Such a guide should be developed. In the interim, existing resources can be utilized to respond to incidents as they occur.

Following damage to a building that serves as a *historic or cultural resource*, Cal OES *Evaluator Training Manual, Unit 3 Building Evaluation, Section 3.3 Historic Structures* (Cal OES, 2016a) is recommended for building safety evaluations.

Even if a building structure has not been significantly damaged, its occupancy may be compromised by environmental hazards, nonstructural damage, or a lack of necessary services. FEMA defines "habitable" as safe, sanitary, and functional. While no published best practice guidance exists for habitability evaluations, this *Guide* presents an organized discussion of the evaluation strategies and issues related to environmental hazards, buildings systems and services, and other code deficiencies.

Incidents can increase exposure to lead, asbestos, hazardous chemicals, carbon monoxide, mold, sewage, communicable disease, and other environmental hazards. Preliminary, limited evaluations ("scans") of selected environmental hazards and nonstructural functions are included as part of the Rapid Evaluation and Detailed Evaluation, based on the available tools and resources of the building safety evaluator. If needed, environmental or building systems evaluations will necessarily be performed later, by specialists. Section 4.4 of this *Guide* presents best practice evaluation strategies for building safety evaluators that encounter environmental hazards on site.

A fully functional building includes building systems such as mechanical, electrical, and plumbing and fire alarms and fire sprinklers. These systems may be damaged by an incident and may prevent or restrict re-occupancy. Section 4.5 of this *Guide* discusses different building systems with regards to the standards that govern them before an incident and temporary standards considerations in the aftermath of an incident.

Allowing residents to remain in their homes until necessary repairs can be made or services restored can minimize the need for temporary shelter and help accelerate household and community recovery. Section 4.8 of this *Guide* presents issues to consider when developing a framework for temporary habitability standards that may allow post-disaster interim use of residential buildings while damage is repaired and utilities restored.

For sharing resources among jurisdictions when responding to an incident, current best practice is the use of FEMA National Incident Management System (NIMS) that provides universally accepted plain language. NIMS

Resource Typing Library Tool[1] should be used for: (1) identifying and typing resources; (2) qualifying, certifying, and credentialing personnel; (3) planning for resources; and (4) acquiring, storing, and inventorying resources. As required by DRRA Section 1241(b), the FEMA National Integration Center (NIC) has revised guidance to ensure the functions of post-disaster building safety evaluation are accurately resource typed within NIMS; this guidance will be issued separately. The following six resource types have been developed and are expected to be defined in the NIMS *Resource Typing Library Tool*:

- Post-disaster Building Safety Evaluator
- Post-disaster Building Safety Evaluation Strike Team Leader
- Post-disaster Building Safety Evaluation Strike Team Technical Supervisor
- Post-disaster Complex Structural Condition Evaluator
- Post-disaster Complex Architectural System Condition Evaluator
- Post-disaster Building Safety Evaluation Team

These resources serve within a Post-disaster Building Safety Evaluation Strike Team. Section 5.3 of this *Guide* provides additional discussion regarding the function and qualifications of each resource type, as well as an example organization of a Strike Team including the listed resources.

A number of professional organizations and governmental agencies provide essential training and education for their members and allied professionals who wish to assist local governments in safety evaluation of their built environment in the aftermath of an incident. Current best practice following earthquake, wind, and flood events is the use of California Governor's Office of Emergency Services (Cal OES) Safety Assessment Program (SAP) training and certification. No best practice training or certifications are in place for other incident types.

Following an incident, the following best practice guidance exists for ensuring safety of post-disaster building safety evaluators responding to the event:

- ATC-20-1 and ATC-45 contain chapters regarding field safety for inspectors, including list of field tools.
- Cal OES SAP *Evaluator Training Manual* (2016a) Chapter 6 on *Field Safety*.

[1] https://rtlt.preptoolkit.org

- The National Institute of Environmental Health Sciences (NIEHS) *Worker Training Program Disaster Preparedness and Response*: https://tools.niehs.nih.gov/wetp/index.cfm?id=556.
- Earthquake Engineering Research Institute (EERI) *Field Guide Appendix B – Pre-Departure Checklist*: https://www.eeri.org/projects/learning-from-earthquakes-lfe/post-earthquake-investigation-field-guide/.
- National Institute for Occupational Safety and Health (NIOSH) *Emergency Response Resources*: https://www.cdc.gov/niosh/emres/default.html.
- Occupational Safety and Health Administration (OSHA) *Emergency Preparedness and Response*: https://www.osha.gov/SLTC/emergencypreparedness/index.html.
- OSHA *Building Assessment, Restoration, and Demolition Assessment, Cleanup, and Repair of Structures*: https://www.osha.gov/SLTC/etools/hurricane/repair.html.
- Centers for Disease Control *Health Information for Disaster Relief Volunteers*: https://www.cdc.gov/disasters/volunteers.html.

Post-disaster building safety evaluators responding to an incident will have different levels of experience and training and thus evaluation quality may vary. No best practice guidelines for evaluation quality assurance exist, but in the interim, it is recommended that personnel in the post-disaster evaluation teams should include a Post-disaster Building Safety Technical Supervisor (as defined per NIMS) with responsibility for quality assurance. In the future, training and certification programs should be developed for the Complex Structural Condition Evaluator and the Complex Architectural Systems Evaluator that go beyond the currently available training programs for Building Safety Evaluators.

In some incidents, subsequent events may raise the question of whether a reevaluation of the initial placard is necessary. No best practice guidelines exist, but the following recommendations are presented in the interim. The concept of indicator buildings, as discussed in Cal OES SAP *Coordinator Manual* Section 2.2.8 (Cal OES, 2016b) and *Managing Buildings in an Emergency* (MBIE, 2018), should be implemented to help determine which buildings need reinspection after aftershocks.

8.4 Best Practices for Emergency Managers and Building Officials

No best practice guidelines exist for incorporating a section, chapter, or annex into emergency plans adopted by the SLTT governments that addresses the evaluation or assessment of buildings following an incident. In the interim, this *Guide* presents an outline of points on post-disaster building safety evaluation that should be included in such a plan, including purpose and scope, situation and assumptions, concept of operations, direction and control, assignment of responsibilities, additional aid documentation, training and certification, and forms and data collection. In addition, the Cal OES SAP *Coordinator Manual* (Cal OES, 2016b) provides additional helpful guidance.

To speed the recovery and reconstruction process, post-disaster safety evaluation should commence immediately following initial response, search, and rescue. The emergency manager, building official, or the official in charge of post-disaster safety evaluation should determine the resources needed to complete safety evaluation in a timely manner. If the local jurisdiction does not have the resources necessary to complete safety evaluation, the local official should seek additional resources. Many states have developed their own training and deployment protocols to meet their own needs. This may constitute a "best practice" for them but may not for a different state. This is especially true when differences in liability protection and workers compensation coverages exist. Until detailed deployment management guidance is developed, the following interim recommendations are provided: (1) Volunteer responder data, including applicable training, experience, and expertise, should be maintained in free nationwide searchable database open to local officials to search for appropriate assistance (it is noted that details of such a database need to be resolved); and (2) Section 2.3 of the Cal OES SAP *Coordinator Manual* (Cal OES, 2016b) provides useful information on deployment management. Additional interim recommendations are provided in this *Guide* for deployment management and prioritization, including use of targeted building safety evaluation teams for essential facilities, grocery/hardware stores, and pharmacies.

It is common practice to provide fencing, barricades, or cordons around damaged structures. Following an earthquake event, *The Interim Guidance for Barricading, Cordoning, Emergency Evaluation and Stabilization of Buildings with Substantial Damage in Disasters* (CALBO, 2013) can be used to make decisions about barricading, cordoning and emergency stabilization. For other incident types, until specific guidance can be developed, the same guidance can be used in the interim.

During and following the post-disaster safety evaluation period, information must be communicated in many formats suitable for many audiences. No best practice guidance currently exists. In the interim, it is recommended that Authorities Having Jurisdiction (AHJ) develop standard operating procedures for communication following incidents.

8.5 Best Practices for Policy Makers

When responding to an incident to assist with post-disaster building safety evaluations, the best practice is for jurisdictions and organizations to adhere to NIMS concepts and principles. Jurisdictions and organizations should conduct resource typing exercises to improve the common understanding of building safety evaluation capabilities and minimum criterion to improve resource sharing and mutual aid. The best practice, nationwide mutual aid system in the United States is the Emergency Management Assistance Compact[2] (EMAC). This legislation has been enacted in 50 states, the District of Columbia, Puerto Rico, Guam and the U.S. Virgin Islands. Membership in EMAC allows for any of these affected states or territories to make requests from other states via their Emergency Management Agency under the authority of the Governor of the state.

Post-disaster building safety evaluators are architects, engineers, and building officials serving in voluntary positions and may face substantial liability exposure when performing voluntary services. No best practice guidance or legislation exists for the protection of the volunteers from liability. In the interim, sample model language published by the American Institute of Architects (AIA, 2019) and American Council of Engineering Companies (ACEC, 2019) can be proposed to create legislation addressing these issues.

In addition to damage to the structure of the building, disasters can increase exposure to lead, asbestos, hazardous chemicals, carbon monoxide, mold, sewage, communicable disease, and other environmental hazards. These hazards affect the habitability of damaged buildings. Best practice guidance for evaluation of common environmental hazards by building safety evaluators is limited to initial scans and is discussed in Chapter 4. Best practice guidance exists for evaluations by specialists but is not covered by this *Guide*.

The loss of function of the building system can also prevent or restrict re-occupancy, or whether there are temporary alternatives that can employed during recovery. No best practice guidance exists for post-disaster

[2] https://www.emacweb.org/

habitability standards with regards to mechanical, electrical, and plumbing components.

Though there are no best practice enforced temporary habitability standards for environmental hazards, and building systems and code issues, the *Guide* discusses in Section 4.8 the *Safe Enough to Stay* (SPUR, 2012) proposal that serves as a potential starting point for local policy makers to develop their own standards. Section 4.8 identifies key questions and issues that need to be addressed to help formulate temporary habitability standards and provides a framework of potential implementation options.

Following earthquake and windstorm and flood events, the best practice guidance available instructs the posting of placards indicating INSPECTED, RESTRICTED USE, and UNSAFE. A posting category can change following a subsequent incident, e.g., earthquake aftershock, if reinspection confirms that damage is more severe. A posting category can also change if reevaluation occurs, such as when a Detailed Evaluation follows an initial Rapid Evaluation. No best practice guidance currently exists. The AHJ will need to set policies for what is required to change or remove a placard.

This *Guide* presents recommended legislation to be developed at the local level in advance of an emergency in order to more effectively perform post-disaster evaluations. This includes passage of Good Samaritan Laws, and legislation to formally provide the authority to inspect and post buildings, deputize inspectors, restrict occupancy, and demolish buildings.

Appendix A
Glossary and Acronyms

A.1 Glossary

Assessment: In this *Guide*, this term is used for all types of reviews that are conducted that are not regarding building safety.

ATC-20-1: Reference to ATC-20-1 report, *Field Manual: Procedures for Postearthquake Safety Evaluation of Buildings*, *Second Edition*, published by the Applied Technology Council (2004).

ATC-45: Reference to AC-45 report, *Field Manual: Safety Evaluation of Buildings after Windstorms and Floods*, published by the Applied Technology Council (2005).

Authority Having Jurisdiction (AHJ): In this *Guide*, this term is used for an entity that can create and administer processes to qualify, certify, and credential personnel for incident-related positions. AHJs include state, tribal, or federal government departments and agencies, training commissions, NGOs, or companies, as well as local organizations such as police, fire, public health, or public works departments.

Building Safety Evaluation: The procedures used to determine building safety resulting in posted placards on damaged buildings.

Dead Load: The weight of all materials of construction incorporated into the building including, but not limited to, walls, floors, roofs, ceilings, stairways, built-in partitions, finishes, cladding, and other similarly incorporated architectural and structural items, and the weight of fixed service equipment, such as cranes, plumbing stacks and risers, electrical feeders, heating, ventilating and air-conditioning systems and automatic sprinkler systems.

Detailed Evaluation: Average of one to four hours per building to provide a careful visual examination of the building and its structural system. Used to evaluate questionable buildings, to identify necessary restrictions on building use or to identify the need for an Engineering Evaluation.

Disaster: An occurrence of a natural catastrophe, technological accident, or human-caused event that has resulted in severe property damage, deaths, and/or multiple injuries.

Emergency: Any incident, whether natural, technological, or human-caused, that necessitates responsive action to protect life or property.

Engineering Evaluation: Detailed engineering investigation of damaged buildings, involving use of construction drawings, damage data, and new structural calculations. Used to evaluate questionable buildings, to determine the extent of damage, and to determine how to stabilize and repair the building.

Habitability: Ability of a building to be occupied. The term applies to not just to residences but also to other types of buildings, such as offices, schools, and stores.

Hazard: Something potentially dangerous or harmful, often the root cause of an unwanted outcome. In this *Guide*, the word "hazard" defines the causes that lead to incidents, including natural and human-caused hazards, such as earthquakes or blast events.

Incident: An occurrence, natural or human-caused, that necessitates a response to protect life or property. In this *Guide*, the word "incident" includes planned events as well as emergencies and/or disasters of all kinds and sizes.

Live Load: A load produced by the use and occupancy of the building or other structure that does not include construction or environmental loads, such as wind load, snow load, rain load, earthquake load, flood load, or dead load. See also **Roof Live Load**.

Mitigation: The capabilities necessary to reduce the loss of life and property from natural and/or human-caused incidents by lessening the impacts of incidents. Mitigation seeks to fix the cycle of disaster damage, reconstruction, and repeated damage. These activities or actions, in most cases, will have a long-term sustained effect. Examples: Structural changes to buildings, elevating utilities, bracing and locking chemical cabinets, properly mounting lighting fixtures, ceiling systems, cutting vegetation to reduce wildland fires.

Mutual Aid: An agreement among emergency responders to lend assistance across jurisdictional boundaries.

Non-congregate Sheltering: Locations where each individual or household has living space that offers some level of privacy (e.g., hotels, motels, casinos, dormitories, retreat camps).

Nonstructural Component: An architectural, mechanical, or electrical component of a building that is permanently installed in, or an integral part of, a building.

Placard: Paper notice posted on buildings by evaluators deputized by the AHJ that indicate the safety evaluation classification of the building, as well as other relevant information. Best practice is the use of placards originating from ATC-20-1, bearing the following titles and colors: INSPECTED (green), RESTRICTED USE (yellow), and UNSAFE (red).

Post: The act of affixing a safety evaluation placard on visible location(s) on a building following an incident.

Post-disaster Building Safety Evaluation Strike Team Leader: FEMA NIMS resource typing definition for individual providing administrative and logistical support for the Post-Disaster Building Safety Evaluation Strike Team.

Post-disaster Building Safety Evaluation Strike Team Technical Supervisor: FEMA NIMS resource typing definition for individual providing enhanced quality assurance and consistent evaluation results in the post-disaster evaluation process. The Technical Supervisor reports to the Post-disaster Building Safety Evaluation Strike Team Leader.

Post-disaster Building Safety Evaluation Strike Team: A term describing the entire collection of resources assigned to conduct and manage post-disaster building safety evaluations.

Post-disaster Building Safety Evaluation Team: FEMA NIMS resource typing definition for a team of two individuals conducting evaluations of damaged or potentially damaged buildings to evaluate safety and habitability for continued use and to assess the need for restricted or prohibited entry. The Safety Evaluation Team conducts Rapid Evaluations or Detailed Evaluations of buildings in incident areas in accordance with ATC-20-1 and ATC-45 guidance; performs a limited initial environmental hazard scan as part of a building safety evaluation and alerts appropriate supervisors, emergency responders, and specialists, in accordance with this *Guide*; performs a limited initial nonstructural hazard evaluation in accordance with ATC-20-1 and ATC-45; posts buildings with placards; and provides the Authority Having Jurisdiction with appropriate reports.

Post-disaster Building Safety Evaluator: FEMA NIMS resource typing definition for individual conducting Rapid Evaluations or Detailed Evaluations of buildings in incident areas, in accordance with ATC-20-1 and

ATC-45 guidance. Evaluators serve in two-person teams in the field and report to the Post-disaster Building Safety Evaluation Strike Team Leader.

Post-disaster Complex Architectural System Condition Evaluator: FEMA NIMS resource typing definition for individual conducting Detailed Evaluations of architecturally complex buildings and architectural systems—such as fire safety systems, environmental systems, building envelope systems, communication systems, accessibility systems, and building transportation systems—in incident areas, to assess incident impacts on habitability and occupancy, in accordance with ATC-20-1, ATC-45, and this *Guide.* Complex Architectural System Condition Evaluators serve in two-person teams in the field (pairing up with a Building Safety or other Complex Evaluator) and report to the Post-disaster Building Safety Evaluation Strike Team Leader.

Post-disaster Complex Structural Condition Evaluator: FEMA NIMS resource typing definition for individual conducting Detailed Evaluations of structurally complex buildings or conditions in incident areas, in accordance with ATC-20-1 and ATC-45 guidance. Complex Structural Condition Evaluators serve in two-person teams in the field (pairing up with a Building Safety or other Complex Evaluator) and report to the Post-disaster Building Safety Evaluation Strike Team Leader.

Rapid Evaluation: Average of 30 minutes per building to provide an initial general evaluation of damage and safety and quickly identify and post unsafe and apparently safe structures, and to identify buildings requiring Detailed Evaluation or necessary restrictions on building use.

Recovery: The capabilities necessary to assist communities affected by an incident to recover effectively.

Resources: Personnel, equipment, teams, supplies, and facilities available or potentially available for assignment to incident operations and for which status is maintained. Resources are described by kind and type and may be used in operational support or supervisory capacities at an incident or at an Emergency Operations Center.

Response: The capabilities necessary to save lives, protect property and the environment, and meet basic human needs after an incident has occurred.

Roof Live Load: A load on a roof produced: (1) during maintenance by workers, equipment, and materials; and (2) during the life of the structure by movable objects, such as planters and other similar small decorative appurtenances that are not occupancy related. An occupancy-related live load on a roof such as rooftop assembly areas, rooftop decks, and vegetative or landscaped roofs with occupiable areas, is considered to be a **live load** rather than a **roof live load**. See also **live load**.

Shelter (Mass Care): A facility where government agencies or preestablished voluntary organizations or other identified partners register, evaluate, and provide disaster services to evacuees who are either without an endpoint destination or need temporary shelter until they can go home or access other lodging services. Meals and water should be available, as well as basic first aid, and some accommodation for household pet sheltering (may be located off-site, if applicable), sleeping space, and hygienic support. In some situations, basic disaster services (e.g., counseling, financial assistance, and referral) may also be provided in a shelter setting. Durable medical equipment, communication aids, and other necessary support assistance may be available at these locations.

Shelter-in-Place: The use of a structure to temporarily separate individuals from a hazard or threat. Sheltering in place is the primary protective action in many cases. Often it is safer for individuals to shelter-in-place than to try to evacuate. Sheltering in place is appropriate when conditions necessitate that individuals seek protection in their home, place of employment, or other location when disaster strikes.

Structural Component: A component of a building that provides gravity- or lateral-load resistance as part of a continuous load path to the foundation, including beams, columns, slabs, braces, walls, wall piers, coupling beams, and connections.

Windshield or Reconnaissance Survey: Conducted by building officials or emergency response managers prior to sending evaluation teams to the field, done either on the ground or by air, to determine the nature and extent of building damage in an area and to prioritize regions that should be evaluated. Buildings are normally not posted with placards during this phase.

A.2 Acronyms

ACM	asbestos containing material
ADA	*The Americans with Disabilities Act*
ADAAG	ADA Accessibility Guidelines
AHJ	Authority Having Jurisdiction
AIA	American Institute of Architects

ALE	Additional Living Expenses
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ATC	Applied Technology Council
BOAF	Building Officials Association of Florida
BOAT	Building Officials Association of Texas
BORP	Building Occupancy Resumption Program
BPAT	Building Performance Assessment Teams
Cal OES	California Governor's Office of Emergency Services
CALBO	California Building Officials
CDC	Centers for Disease Control
CEA	California Earthquake Authority
CEDAR	Code Enforcement Disaster Assistance Response Program
CERT	Community Emergency Response Team
CO	carbon monoxide
DHS	Department of Homeland Security
DRRA	*Disaster Recovery Reform Act*
EERI	Earthquake Engineering Research Institute
EIT	Engineer-in-Training
EMAC	Emergency Management Assistance Compact
EOC	emergency operations center
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FHA	Federal Housing Administration
FY	fiscal year
GEER	Geotechnical Extreme Events Reconnaissance
GIS	Geographic Information System
GPS	Global Positioning System
HDDS	Hazard Data Distribution System

HHC	Health & Hospital Corporation
HQS	Housing Quality Standards
HUD	U.S. Department of Housing and Urban Development
HVAC	heating, ventilation, air-conditioning
IA	Individual Assistance
IBC	International Building Code
I-BEAM	Indiana Building Emergency Assessment and Monitoring
ICC	International Code Council
ICS	Incident Command System
IDA	Initial Damage Assessment
IEBC	International Existing Building Code
IO	Immediate Occupancy
IPMC	International Property Maintenance Code
IRC	International Residential Code
ISEEER	Interdisciplinary Science and Engineering Extreme Events Reconnaissance
LSU	Louisiana State University
MAC	Multiagency Coordination Groups
MAT	Mitigation Assessment Team
MEP	mechanical electrical plumbing
MOU	memorandum of understanding
MRPs	mission ready package
MSU	mobile support unit
NCSEA	National Council of Structural Engineers Associations
NEC	National Electrical Code
NEHRP	National Earthquake Hazards Reduction Program
NFIP	National Flood Insurance Program
NFPA	National Fire Protection Association
NHERI	Natural Hazards Engineering Research Infrastructure
NHPA	*National Historic Preservation Act*

NIC	National Integration Center
NIEHS	National Institute of Environmental Health Sciences
NIMS	National Incident Management System
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
NRF	National Response Framework
NSF	National Science Foundation
NWS	National Weather Service
OBOA	Ohio Building Officials Association
OSHA	Occupational Safety and Health Administration
PA	Public Assistance
PDA	Preliminary Damage Assessment
PE	Professional Engineer
PETS	*Pets Evacuation and Transportation Standards Act*
SAP	Safety Assessment Program
SAVE	Structural Assessment and Visual Evaluation
SE	Structural Engineer
SEAOC	Structural Engineers Association of California
SEAOT	Structural Engineers Association of Texas
SEER	Structural Engineering Emergency Response
SFHA	Special Flood Hazard Area
SHPO	State Historic Preservation Officer
SLTT	state, local, tribal, territorial
SPUR	San Francisco Bay Area Planning and Urban Research Association
SSEER	Social Science Extreme Events Reconnaissance
STAR	State of Texas Request
StEER	Structural Engineering Extreme Events Reconnaissance
THPO	Tribal Historic Preservation Officer
UAV	Unmanned Aerial Vehicles

UPC	Uniform Plumbing Code
URM	unreinforced masonry
USGS	U.S. Geological Survey
USNG	U.S. National Grid
UTM	Universal Transverse Mercator
VOAD	Voluntary Organizations Active in Disaster
VPA	*Volunteer Protection Act*
WAsafe	Washington Safety Assessment Facility Evaluators

Appendix B

Referenced Codes and Standards

This *Guide* makes references to the following editions of U.S. based codes and standards, where relevant:

ASCE/SEI 7-16, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, Structural Engineering Institute of American Society of Civil Engineers, Reston, Virginia.

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