17th World Conference on Earthquake Engineering, 17WCEE

Sendai, Japan - September 13th to 18th 2020

POST-DISASTER SAFETY EVALUATION GUIDANCE

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Abstract

In 2018, the 115th United States Congress (2017-2018) passed the Disaster Recovery Reform Act of 2018 (DRRA) with Section 1241(a) that requires FEMA to publish a report providing guidance on the best practices for post-disaster evaluation of buildings for both structural safety and habitability. This presentation will provide an overview of the resulting FEMA P-2055 publication. The publication 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.

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 paper provides an overview of the publication and focuses on the key conclusions of the document that are applicable to many different incident types that may occur anywhere in the world.

Keywords: multi-hazard, post-disaster, safety, emergency management, evaluation

1. Introduction

In November 2019, the Federal Emergency Management Agency (FEMA) published FEMA P-2055, *Post-disaster Safety Evaluation Guidance, Report on the Current State of Practice, including Recommendations Related to Structural and Nonstructural Safety and Habitability* [1], in response to Section 1241(a) of the Disaster Recovery Reform Act of 2018 (DRRA) passed by the United States Congress to improve the nation's capacity to respond to and recover from catastrophic events. Incident types covered by this *Guide* include earthquake; hurricane; tornado; flooding; tsunami; volcano; landslide and other land instabilities; snow, hail, and ice storms; fire; and explosion, as well as multi-hazard incidents. However, this paper focuses on only the findings related to earthquakes.

The *Guide* was developed by a technical team managed by the Applied Technology Council (ATC)—under the direction of FEMA, with feedback from a project review panel and a stakeholder workshop. The *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 building safety and habitability. 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.

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. 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.

Where available, the *Guide* identifies best practices for implementation by the following three target audiences identified:

- Architects, engineers, and building code officials directly involved in post-disaster building safety evaluation.
- Emergency managers and health officials who may be involved in management of the post-disaster evaluation process, including environmental health issues.
- Policy makers.

Note that FEMA P-2055 is written to be consistent with the overall current post-disaster evaluation process in the United States. Fig. 1 illustrates the topics covered as they fit on the timeline of an incident. The focus of FEMA P-2055 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.

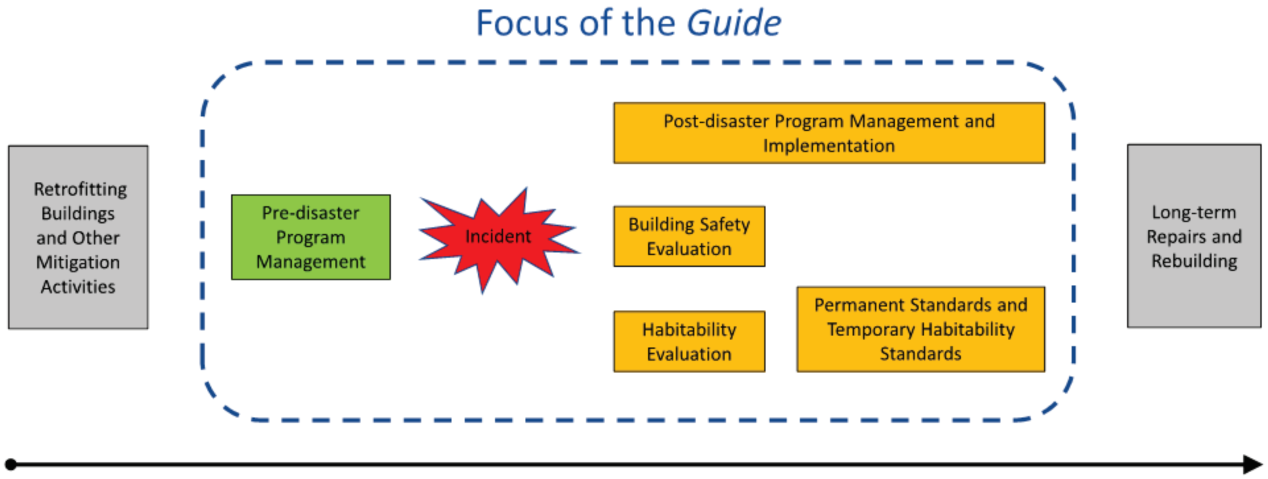

Fig. 1 Graphic illustrating building safety evaluation topics covered. The horizontal arrow indicates time in relation to the incident. Topics indicated in gray are outside of the scope of this paper and FEMA P-2055.

2. Post-earthquake Structural and Nonstructural Safety Evaluation

Post-disaster building safety evaluations are a key activity following an earthquake, 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.

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.

There are well-established post-disaster building safety evaluation guidelines for earthquakes. FEMA P-2055 recommends the current second edition of the ATC-20-1, *Field Manual: Procedures for Postearthquake Safety Evaluation of Buildings* [2], for use in evaluating U.S. buildings following earthquakes. This document is widely used in other countries; however, adaptation to local building inventory may be necessary. An example is the ATC-20-1 *Bhutan Field Manual* [3] that accounts for Bhutan's vernacular buildings, as well as the country's cultural and governmental context.

Procedures in ATC-20-1 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 following an earthquake event. The ATC-20-1 methodology is unique in its ability to provide a rapid evaluation of the extent and significance of reductions in lateral force-resisting and gravity load-carrying capacity. ATC-20-1 provides 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 Fig. 2 for examples of the placards. Also included in ATC-20-1 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.


INSPECTED
LAWFUL OCCUPANCY PERMITTED
This structure has been inspected (as indicated below) and no apparent structural hazard has been found.
Inspected Exterior Only
Inspected Exterior and Interior
Report any unsafe condition to local authorities; reinspection may be required.
Inspector Comments:
Facility Name and Address:
Date
Time
(Caution: Aftershocks since inspection may increase damage and risk.)
This facility was inspected under emergency conditions for:
(Jurisdiction)
Inspector ID / Agency
Do Not Remove, Alter, or Cover this Placard until Authorized by Governing Authority

RESTRICTED USE
Caution: This structure has been inspected and found to be damaged as described below:
Entry, occupancy, and lawful use are restricted as indicated below:
Facility Name and Address:
Date
Time
(Caution: Aftershocks since inspection may increase damage and risk.)
This facility was inspected under emergency conditions for:
(Jurisdiction)
Inspector ID / Agency
Do Not Remove, Alter, or Cover this Placard until Authorized by Governing Authority

UNSAFE
DO NOT ENTER OR OCCUPY
(THIS PLACARD IS NOT A DEMOLITION ORDER)
This structure has been inspected, found to be seriously damaged and is unsafe to occupy, as described below:
Do not enter, except as specifically authorized in writing by jurisdiction. Entry may result in death or injury.
Facility Name and Address:
Date
Time
This facility was inspected under emergency conditions for:
(Jurisdiction)
Inspector ID / Agency
Do Not Remove, Alter, or Cover this Placard until Authorized by Governing Authority

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

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.

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.

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, and typically conducted by structural engineering, geotechnical, or hydrologic consultants hired by the building owner. Engineering Evaluation guidance is available for select building types in FEMA 352, *Recommended Postearthquake Evaluation and Repair Criteria for Welded Steel Moment-Frame Buildings* [4] and FEMA 306, *Evaluation of Earthquake-Damaged Concrete and Masonry Wall Buildings: Basic Procedures* [5].

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. FEMA 306 and FEMA 352 provide guidance for Engineering Evaluations of concrete and masonry wall buildings and steel moment frame buildings.

Although considered the international defacto standard for post-earthquake safety evaluation, ATC-20-1 can be enhanced by incorporating 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* [6] 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. In addition, 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 [7]. 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.

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* [8] 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.
- 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.

FEMA P-2055 recommends use of the 2017 New Zealand *Field Guide – Geotechnical Assessment* is recommended for use instead of the geotechnical chapter in ATC-20-1 with necessary adjustments to laws, jurisdictional authority, emergency management personnel and procedures, applicable in the United States.

An earthquake can cause secondary incidents such as fire or tsunamis. The secondary incident may be small and limited in scope or may be more widespread and destructive than the earthquake. The secondary incident may occur seemingly simultaneously, such as an earthquake-induced tsunami, or fires may 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.

When an incident occurs, one of the first considerations should be to evaluate the potential for secondary 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.

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.

3. Post-earthquake Habitability Evaluations

Even if the structural and nonstructural systems of a building have not been significantly damaged and do not pose a safety risk according to the procedures outlined in the previous section, occupancy may be compromised by other forms of nonstructural damage, environmental hazards, and a lack of necessary services, such as fire protection, plumbing, or elevators.

No standardized guidance was identified for evaluating habitability of buildings following earthquakes, but FEMA P-2055 presents strategies for evaluating environmental hazards and an overview of available permanent and temporary standards governing building systems or services.

3.1 Environmental Hazard Evaluation

Environmental hazards can restrict habitability. ATC-20-1 provides only limited, initial evaluation of common environmental hazards (a “scan”) as part of a Rapid Evaluation, such as environmental scans related to downed power lines and gas leaks. Habitability evaluations have been conducted in past incidents, but the approaches are less standardized than those used for building safety evaluations.

The following common environmental hazards can occur post-earthquake:

- Natural gas, carbon monoxide, or general chemical release: If presence is detected, the building safety evaluator should evacuate the building and contact fire department, utility, or hazard materials unit for remediation.
- Damaged asbestos or lead-based paint containing components: If the building is known to contain such materials or if damaged components are visible, the building safety evaluator should evacuate the area, cordon it off appropriately, and contact accredited abatement contractors.
- Wild, stray, dead animals and insects: The building safety evaluator should avoid contact and contact public health officials.
- Refuse and debris: The building safety evaluator should avoid contact and contact public health officials.

FEMA P-2055 provides evaluation strategies for building safety evaluators for specific environmental hazards, as well as strategies for specialists or owners.

3.2 Building Systems and Services

Building codes and laws 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. FEMA P-2055 did not identify any temporary standards governing these components following an earthquake, but it provides an overview of the standards that set the minimum requirements and possible considerations post-earthquake. For example, a functional building includes mechanical, electrical, plumbing, fire alarm, and fire sprinkler systems. If these systems are damaged by an earthquake, 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 Authority Having Jurisdiction 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 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)).

3.3 Framework for Developing Temporary Habitability Policies

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. FEMA P-2055 did not identify any existing policies for temporary habitability; thus, the report presents a possible framework for developing policies for temporary habitability with the discussions summarized here.

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. FEMA P-2055 lists questions, and related discussion are provided to help give communities and their leaders a start on the issues including technical (e.g., is a second means of egress needed, should the requirement of heat depend on the climate) and administrative and policy (e.g., should habitability requirements vary by incident type, should requirements for single-family dwellings be more permissive than those for multi-family residential buildings). A proposed temporary habitability standard is *Safe Enough to Stay* [9] 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.

FEMA P-2055 identifies five approach options for implementing temporary habitability policies (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 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.

4. Post-earthquake Safety Evaluation Program Management

Past earthquakes 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.

4.1 Resource Typing

In the United States, the National Incident Management System (NIMS), developed by the Department of Homeland Security, provides a scalable, common, nationwide approach to guide 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 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. 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.

The FEMA National Integration Center (NIC) is responsible for establishing and maintaining the *Resource Typing Library Tool* [10] of resource typing definitions. FEMA P-2055 presents the following new resource types that are currently in process of being incorporated by NIC into the *Resource Typing Library Tool*.

- *Post-disaster Building Safety Evaluators* conduct Rapid Evaluations and Detailed Evaluations of buildings in two-person teams. Three types of evaluations are identified: Type 1 can conduct Detailed Evaluations, Type 2 can conduct Rapid Evaluations, Type 3 can assist Type 1 or Type 2 evaluators.

- *Post-disaster Building Safety Evaluation Strike 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.
- *Post-disaster Building Safety Evaluation Strike Team Technical Supervisor* reports to the Team Leader and provides enhanced quality assurance and more consistent results in the post-disaster evaluation process. 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.
- *Post-disaster Complex Structural Condition Evaluator* is selectively deployed to evaluate structurally complex buildings or conditions in incident areas.
- *Post-disaster 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.
- *Post-disaster Building Safety Evaluation Team* is made up of two people that perform the field evaluations and post buildings. The number of teams will depend on the scale of the incident and the extent of damage. Fig. 3 presents an example organization of this team.

More detail on minimum qualifications and responsibilities is provided in FEMA P-2055.

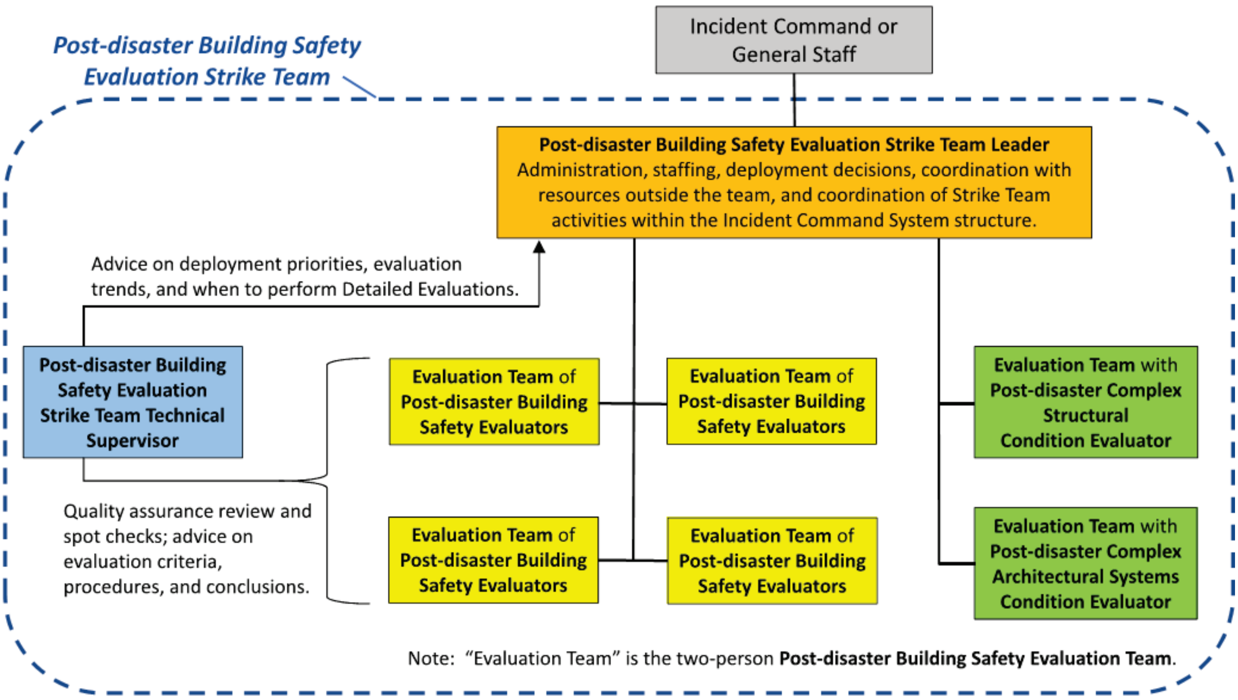

Fig. 3 Example organization chart for the Post-disaster Building Safety Evaluation Strike Team

5. Acknowledgements

This paper was prepared by the ATC-137-2 Project Technical Committee that developed FEMA P-2055 for the Federal Emergency Management Agency. The work forming the basis for this publication was conducted pursuant to a contract with the Federal Emergency Management Agency. The substance of such work is dedicated to the public. The Applied Technology Council managed the project. The author(s) are solely responsible for the accuracy of statements or interpretations contained in this publication. No warranty is offered with regard to the results, findings and recommendations contained herein, either by the Federal Emergency Management Agency, the Applied Technology Council, its directors, members or employees. These organizations and individuals do not assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any of the information, product or processes included in this publication. FEMA P-2055 benefited greatly from feedback from the ATC-137-2 Project Review Panel, participants of the online stakeholder workshop, and numerous FEMA staff reviewers.

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