BRITISH COLUMBIA
POST-DISASTER BUILDING ASSESSMENT FRAMEWORK AND RECOMMENDATIONS COMPANION DOCUMENT:
RESOURCES AND REFERENCES

BC HOUSING
JUSTICE INSTITUTE of BRITISH COLUMBIA
ENGINEERS & GEOSCIENTISTS BRITISH COLUMBIA
AIBC ARCHITECTURAL INSTITUTE OF BRITISH COLUMBIA

BRITISH COLUMBIA POST-DISASTER BUILDING ASSESSMENT FRAMEWORK AND RECOMMENDATIONS COMPANION MANUAL: RESOURCES AND REFERENCES

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OVERVIEW

This document provides links and resources to support the Post-Disaster Building Assessment Framework and Recommendations manual (BC PDBA Framework) which emerged from the BC Post-Disaster Building Assessment (PDBA) research project. The PDBA project was conducted through a partnership between BC Housing, Justice Institute of British Columbia (JIBC), Engineers and Geoscientists BC, and the Architectural Institute of British Columbia (AIBC). The two-year applied research project was funded through the Canadian Safety and Security Program, a federal program of Defence Research and Development Canada's Centre for Security Science, in partnership with Public Safety Canada. The PDBA Framework presents a series of recommendations for developing and implementing PDBA operations.

The project team developed an overall framework and recommendations for building damage and safety assessment following an emergency or disaster. The goal of PDBA programs is to enable communities to more rapidly assess the safety of structures and allow people to remain in, or return to their homes and businesses as soon as possible. The PDBA framework and recommendations identify concepts, tools, models, processes and approaches which support community-level emergency planning and safety assessment.

The PDBA recommendations were derived from applied research involving review of relevant academic and professional literature, interviews with national and international key informants, and input from stakeholders in provincial and community-level emergency management. The links and resources in this companion manual emerged from data and analysis obtained through this research.

Note that the resources and references listed here emerged through research conducted between 2016 and 2018. Some of the resources are of historical events or programs. Others are operational documents which were current at the time of data collection. Some of the programs and material may have been updated, supplemented, or replaced by other processes and documents. Please refer to the host organizations and agencies for the most current information and resources.

The core research team consisted of Steven Bibby, Ron Bowles, Robyn Fenton, Marguerite Francis-La Quinte, Pete Learoyd, Peter Mitchell, Dawn Ursuliak, and Cindy Moran.

ACKNOWLEDGEMENTS

The project was funded by the Canadian Safety and Security Program, a federal program led by Defence Research and Development Canada's Centre for Security Science (DRDC CSS) in partnership with Public Safety Canada.

We would also like to acknowledge the support of project partners: BC Housing, Justice Institute of British Columbia, Engineers and Geoscientists BC, and the Architectural Institute of British Columbia.

Most of all, we thank the many participants who contributed their time and their expertise to further the research and the recommendations contained within this Framework.

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INTRODUCTION

This document provides links and resources to support the *BC Post-Disaster Building Assessment Framework and Recommendations* manual (PDBA Framework) which emerged from the BC Post-Disaster Building Assessment (PDBA) research project. The PDBA Framework presents a series of recommendations for developing and implementing PDBA operations.

USING THE PDBA COMPANION MANUAL

The *PDBA Companion Manual* contains links, examples, resources, and references gathered in the overall PDBA research project. Note that resources such as this *PDBA Companion Manual* are necessarily out-of-date even as they are being released. The core research for this project occurred in 2017 and 2018. Many of the programs and resources referred to in the manual continue to evolve and change. The material in the *PDBA Companion Manual* reflects our understanding of PDBA processes and available information during that period. Our hope is that the *PDBA Companion Manual* will be maintained on an ongoing basis, but it should be read as a resource reflecting information available during the initial research process.

The PDBA Companion Manual has several sections, and much of the information in the manual will be found in multiple sections of the document.

Section 1 contains information that supplements specific recommendations in the PDBA Framework document. In effect, Section 1 provides footnotes to the recommendations. Many of these notes are very brief and are intended to provide supplemental commentary, examples, or links to other resources. Some of these notes may reference more comprehensive material contain in subsequent sections of the Companion Manual.

Section 2 contains background information and resources pertaining to specific PDBA topics, such as types of PDBA systems, use of placards, and links to resources such as forms and checklists. As noted above, the material in this section represented the best information available during the research phase of the project. PDBA programs and procedures are under continual revision. Please refer to the host organizations and agencies for the most current information and resources.

Section 3 contains an annotated list of documents describing PDBA processes in Italy, New Zealand, and Japan. These documents helped the research team understand post disaster building assessment in action.

Section 4 is a list of references and resources that informed the development of the *BC PDBA Framework and Resources.*

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PDBA CHAPTER RESOURCES

INTRODUCTION

Section 1 contains information that supplements specific recommendations in the PDBA Framework document. In effect, Section 1 provides footnotes to the recommendations. Many of these notes are very brief and are intended to provide supplemental commentary, examples, or links to other resources. Some of these notes may reference more comprehensive material contain in subsequent sections of the PDBA Companion Manual.

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1.1 GOVERNANCE

GOALS OF PDBA

The research team noted that various programs include assessment for immediate life safety and evacuation, determination of short-term use, long-term remediation and repair, identification of hazards internal to the building (i.e., risk of collapse, presence of hazardous materials) and external threats (i.e., potential collapse of neighbouring structures, geotechnical hazards, ongoing flooding or aftershocks, etc.).

Various programs examined in this study identified different goals for both overall PDBA and for various types of assessment procedures. In addition, the team documented an evolution in the New Zealand program over several major events.

SOURCE	NOTES
New Zealand Society for Earthquake Engineering (2011). *Building Safety Evaluation Following the Canterbury Earthquakes* p. 7	The common objective of these evaluation procedures is to determine whether damaged or potentially damaged buildings are likely to be safe for use, or if entry should be restricted or prohibited. These objectives are common to building safety evaluation procedures developed in other countries of high seismicity.
New Zealand Society for Earthquake Engineering (2009). p. 8	… provide for public safety. People need to be kept from entering or using unsafe buildings, or be informed that essential activities may continue where structures are assessed as safe. … Important short-term aims for inspections include: • safe use of streets adjacent to damaged buildings • safe occupation of buildings for: o continued use, especially emergency facilities o minimisation of impact on commercial activity o minimisation of displacement of people • assessment of the need for temporary works such as shoring, temporary securing and making safe • saving property from unnecessary demolition o conserving heritage fabric o minimising economic impact for the owners and community Inspections also contribute to longer-term recovery measures, by assisting with: • cost of damage estimates • determining the aid and resources required for permanent recovery • obtaining engineering, scientific and insurance data to improve disaster mitigation measures.
New Zealand Ministry of Business, Innovation and Employment (2014). Field Guide: *Rapid Post Disaster Building Usability Assessment: Earthquakes.* p. 9.	The objective of the rapid building assessment is to quickly establish the usability of buildings and associated infrastructure where functions may be compromised by a hazard event. Hazard events include earthquake, flood, landslide, rock-fall, volcanic eruption, storm surge, tsunami, explosion, or other event with life safety, residential or business consequences.

SOURCE	NOTES
New Zealand Ministry of Business, Innovation and Employment (2017). F*ield Guide: Rapid Post Disaster Building Usability Assessment: Geotechnical.* p. 13.	The purpose of the geotechnical assessment in the RBA process is to restrict people from accessing or occupying areas at risk from land instability. The assessment needs to provide a prompt evaluation of the life safety risk associated with land instability, with respect to the potential impact on properties.
Baggio et al. (2007). *Field Manual for post-earthquake damage and safety assessment and short term countermeasures (AeDES).* pp. 1 – 2	… AeDES…aims at surveying the typological, damage and usability characteristics of residential buildings, in the emergency phase following an earthquake… {The data from these assessments is} useful for a first evaluation of the repair and/or retrofit costs, allowing to create costs scenarios for different unitary contributions associated to different damage thresholds. … Despite the fact that, at least in Italy, a definition of usability has never been codified, usability may be related to the need of using the building during the seismic emergency, being reasonably safe from the risk of significant damage to people. For this reason, the usability assessment does not aim at safeguarding the construction from further damages, but only at preserving the life of occupants.
BC Housing, 2017. *Field Manual: Rapid Damage Assessment.* p. 1.	The intent of RDA is to enable people to remain in their buildings, or return to their buildings as quickly and as safely as possible after a damaging event.
Applied technology Council (1989). ATC 20: *Procedures for Postearthquake Safety Evaluation of Buildings.* p. 15.	Within the first few hours or days after the earthquake…building Evaluation Procedure[s … are} designed to be used to quickly post the apparently safe and the obviously unsafe structures.
Applied Technology Council (1995). ATC 20-2: *Addendum to the ATC-20 Postearthquake Safety Evaluation Procedures.* p. 15.	When an earthquake disaster strikes a community, there is an immediate need for building safety inspections to identify those structures that can be fully or partially occupied, to quickly determine the safety of essential facilities, and to identify safe shelter for those left homeless.
Ghilarducci, M. (2015). *Post-Disaster Safety Assessment Program: Guideline to the activation and utilization of program resources.* p. 4.	The goal of SAP (safety assessment programs) is to help local government perform accurate facility safety assessments as quickly as possible. This will allow people to use safe homes and businesses, and ensure that people are prohibited from entering unsafe structures after a disaster. … Safety assessment is the evaluation of facilities following a disaster to determine the condition of buildings and infrastructure for use and occupancy. These assessments are not intended to identify or quantify damage, but to categorize facilities as to their safety.
LESSLOSS (2007). Deliverable 13.13 – Analysis and Reporting on State-of-the-Art on Post-earthquake Safety and Damage Assessment.	Goals for selected countries.
Cyprus p. 19.	In Cyprus, the damage assessment is performed after completing the safety assessment. The safety assessment aims mainly at deciding whether constructions can continue to be used. On the other hand, the damage assessment aims at evaluating the cost of intervention for each building. Short term countermeasures are eventually proposed and applied to guarantee private and public safety.

SOURCE	NOTES
Greece p. 27.	The safety assessment (in its first step) aims mainly at deciding upon usability, i.e. establishing if a building can be used (green) or not (yellow or red). Moreover, it aims at identifying a appropriate provisions for very dangerous situations, i.e. urgent short term countermeasures for immediate risk reduction. The second step of the usability assessment has the scope of assessing as soon as possible after the earthquake the amount of unusable buildings and the number of people needing shelter, as well as to present an overview of the damage to the building stock in the area. On the other hand, the damage assessment aims at evaluating the repair or reconstruction works and allocating funds accordingly.
Italy p. 35.	In Italy, damage and safety assessment are jointly performed. The safety assessment aims mainly at distinguishing safe and unsafe buildings and evaluating the short term countermeasures necessary to make buildings safe. On the other hand, the damage assessment aims at establishing the overall cost of repair, upgrading or retrofitting in the affected area.
Goretti, A., & Di Pasuquale, G. (2002). An overview of post-earthquake damage assessment in Italy. *EERI Invitational Workshop,* 19 – 20 September, 2002, Pasadena, CA.	Goretti and Di Pasquale reviewed a number of PDBA systems in 2002. The following table is adapted from their analysis of usability and damage components of these systems. They noted that all systems in their review examined the usability of buildings; Italy, Turkey, and Japan explicitly included damage assessment in their models, while Greece and the USA did not.

Country	Usability Survey	Steps	Damage Survey	Survey
Italy	Short term use of the building	2	Establish overall amount of direct economic loss	Joint
Greece	Short term use of the building	2	Not performed	
Turkey	Short term use of the building	1	Establish financial contribution for each building	Distinct
USA	Short term use of the building	3	Not performed	
Japan	Short term use of the building	1	Suggestion for long term use of buildings	Distinct

AREAS OF FOCUS

Comments from Study Participants

STAKEHOLDER	AREAS OF FOCUS	NOTES OR COMMENTS
Initial Response	Initial response after an incident focuses on life safety and rescue.	"In first days in the cordoned areas, we were just doing rescue. The focus at the beginning was on use of trained USAR and fire fighters, about identifying contamination in the basement, wires, hazards, buildings that were about to collapse; it took two days to stabilize the building. When the council placard teams come in, they had a much different focus." Interviews, New Zealand. "In first hours, if you are pulling out victims, not really damage assessment. After one to three days, things are different." BC Stakeholders Workshop
First Few Days	After the initial phase, focus shifts to identifying the usability of buildings.	"The first assessments critical in the first couple days – ours {building assessors] took longer, and the two teams had to part ways. Relationship splits in second week – we just had a different focus than the fire fighters and USAR teams." Interviews, Christchurch, New Zealand. "Their [USAR teams'} assessment criteria was very different – get people out of the houses; there was frustration between building inspectors and USAR to the point we had to go in and re-evaluate some areas – USAR would placard as white, but we'd come back and do yellow." Interviews, Christchurch, New Zealand. "What can be utilized? Is one part safe? Structurally the house is fine. But the sliding doors blown out. Take those doors out and building could be fine. In [a rural community], people were quite cut off, so more housing was more acute – where do you put people if you take them out of their houses?" Interviews, Christchurch, New Zealand.

STAKEHOLDER	AREAS OF FOCUS	NOTES OR COMMENTS
Difference between "safety" and "usability" focus	Changing focus changes the nature of assessment processes and decision-making	"Goal of rapid assessment is safety – is it safe to be in that structure? But we also need to consider usability – we're already there, so should we be doing a usability assessment? That's not as simple as a safety check – need to consider environmental, public health risks, is it "safe" if no water?" BC Stakeholder Workshop "Should people be able to sleep in their home if they want to? In Italy, people were afraid to stay in their homes, which is understandable based on building type, etc. In the BC wild fires, people wanted to be in their own homes." BC Stakeholder Workshop
Changing Priorities over time	While fundamental goals of PDBA are constant, priorities and focus of assessment may change based on changing conditions.	"The goal post of assessment change – for example, you need to consider the effects of accumulated damage from multiple events or aftershocks." Interviews, Christchurch, New Zealand. "Evaluation is dependant on objectives such as life safety, short term usability, long term repair, insurance." Interviews, New Zealand. {After a time,] "damage assessment takes on a different perspective. Insurance or long term perspectives different." Interviews, Christchurch, New Zealand.

RESOURCES DESCRIBING ELEMENTS IN A PDBA SYSTEM

The research team found little documentation describing a comprehensive PDBA system. Most of the resources available focus on assessment procedures themselves and resources for individual assessors and/or teams.

The "System of Systems" diagram from the PDBA Framework document is a synthesis of the components of a robust PDBA system. The research team identified the following 11 elements:

- Governance
- Administration
- (Developing) Situational Awareness
- Operations
- Information Management
- (Management and Operations of) Assessment Teams
- Building Assessment Procedures
- (The Concept of) Building Status
- Placards
- Assessment Personnel
- Training

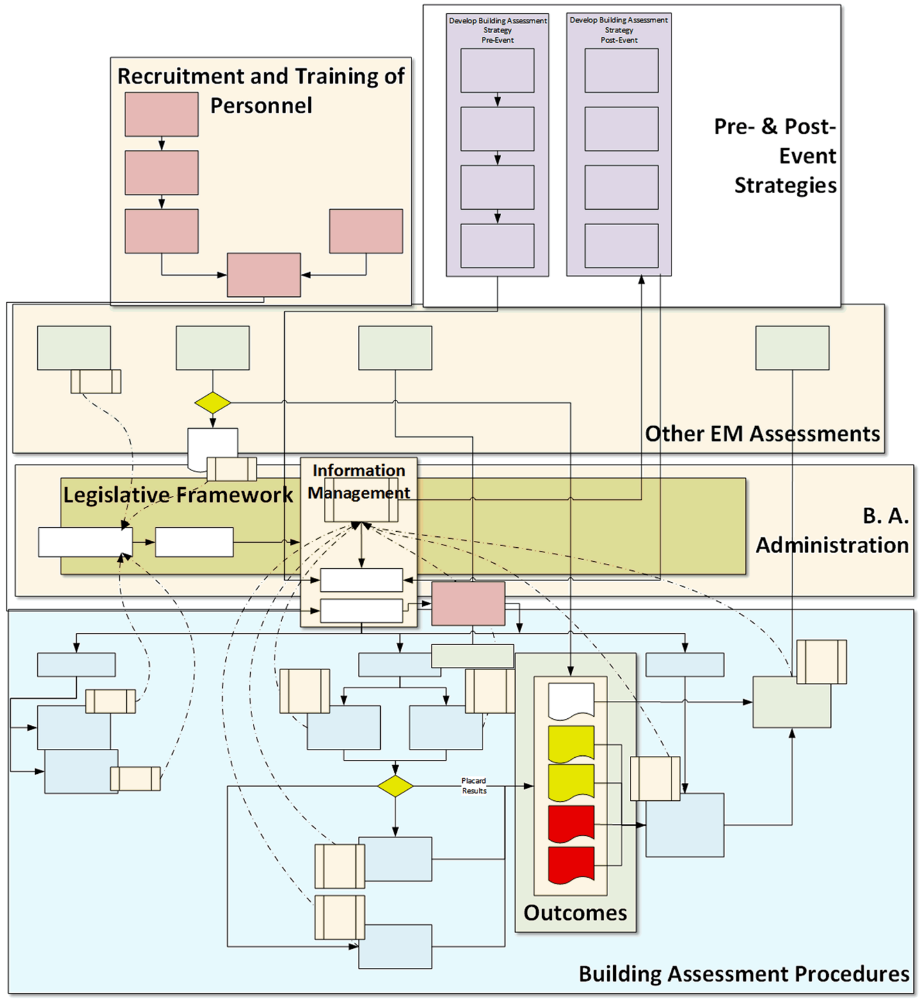


Figure 1. Elements in a PDBA System

As noted above, most of the documentation available on PDBA is focused on assessment procedures, rather than on the overall PDBA system and its relationship to PDBA operations. The following resources provide examples of elements or resources identified in existing PDBA systems:

BC Housing (2018). Coordination of Damage Assessment.

Elements

- Pre-Deployment Checklists
- Health
- Employment and Finances
- Personal and Family Life
- Job Descriptions
- Go-kit (Equipment Lists)
- EOC Function and Building Damage Assessment Unit description
- Information for Building Owners

Comments

This document provides information and checklists to support PDBA operations from the perspective of the PDBA coordinator. The document is a handout given as part of training for damage assessment coordinators.

FEMA (2016). Damage assessment operations manual: A Guide to assessing damage and impact.

Elements

- Concept of Operations
- Roles & Responsibilities
- Evaluating Damage and Impact for FEMA Public Assistance Programs
- Evaluating Damage and Impact for FEMA Individual Assistance Programs
- Damage Assessment Methods
- Integration of Geospatial Analysis and Technology
- Integration of Mobile Technology

Comments

Document provided by FEMA with the goals of promoting accuracy by clearly defining information and documentation that should be collected to assess damage, promote consistency by standardizing criteria used to assess damage, and promote efficiency by empowering emergency management at all levels with the structure and information needed to streamline damage assessment efforts.

BC Housing (2017). Field manual: Rapid Damage Assessment.

Elements

- Post Emergency Response
- Personal Safety and Equipment
- Rapid Damage Assessment (Procedures, criteria, considerations, and forms)
- Posting Structures and Hazards (Placards)
- Building Evacuation
- Structural Basics
- Detailed Damage Assessment
- Geotechnical Hazards
- Non-Structural Hazards
- Pre-deployment Checklist
- Support to Occupants & Response Workers
- Municipal/Agency Officials
- Inspection of Critical Infrastructure

Comments

Field manual for BC Housing's Rapid Damage Assessment program, which focuses on preparing non-professionals such as building owners and occupants with the basic skills and training necessary to perform Rapid Damage Assessment.

New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). Field guide: Rapid post disaster building usability assessment: Earthquakes.

Elements

- Scope
- Field Safety
- Building Assessment Overview
- Residential Rapid Assessment – Simple Residential Buildings
- Level 1 Rapid Assessment – Complex Residential and all Non-Residential Buildings
- Level 2 Rapid Assessment – Complex Residential and all Non-Residential Buildings
- Instruction on how to complete the assessment forms

- Assessing Specific Building Types
- Geotechnical Hazards
- Non-structural Hazards
- Essential Facilities
- Resources Requirement in the field
- Dealing with People
- Simple First Aid Procedures
- Sample Memorandum of Understanding (MoU) for Assessors

Comments

The New Zealand Field Manuals are aimed at the level of individual assessors, although they do address larger issue concerns. Manuals are available for earthquake, flooding, and geotechnical hazards.

Applied Technology Council (1989). ATC 20: Procedures for postearthquake safety evaluation of buildings.

Elements

- General Procedures for Building Safety Evaluation
- Rapid Evaluation Method
- Detail Evaluation Method
- Inspection of Wood Frame Structures
- Inspection of Masonry Structures
- Inspection of Tilt-up Structures
- Inspection of Concrete Structures
- Inspection of Steel Frame Structures
- Inspection of Geotechnical Hazards
- Inspection of non-structural hazards
- Special Issues for Essential Facilities
- Engineering Evaluation Method
- Field Safety for Engineers

Comments

ATC 20 provides guidelines and procedures for postearthquake safety evaluation of building types commonly found in the United States. The process is focused on engineering assessment of buildings and does not directly address larger system issues.

Ministry of Civil Defence & Emergency Management (CDEM) (2013). Rapid impact assessment: Information for the CDEM Section [IS 14/13].

Elements

- Rapid Impact Assessment
- Preparation during Readiness
- Activation during Response
- Forms

Comments

This document provides a broad overview of the concept of rapid impact assessment – a broader focus than building damage assessment. A robust PDBA system should include processes for both overall area assessment and management of building assessment itself.

Ministry of Civil Defence & Emergency Management (CDEM) (2013). Director's guideline for CDEM Group and Local Controllers [DGL06/08].

Elements

- Complying with the CDEM Act
- Preparing to operate as a Controller
- Relationships with Stakeholders
- Directing and coordinating the response
- Providing public education and public information
- Political interface
- Phases of a recover operation

Comments

This document is aimed at Civil Defence Group and Local Controllers who have overall responsibility for response after an emergency. While the information does not directly address PDBA, it does provide an overview of response at a larger level.

PDBA ADMINISTRATIVE STRUCTURES AND OVERLAP WITH EMERGENCY MANAGEMENT

PDBA is typically organized at the local government level in British Columbia, with PDBA operations housed in either Operations or Planning sections in the Incident Command System structure.

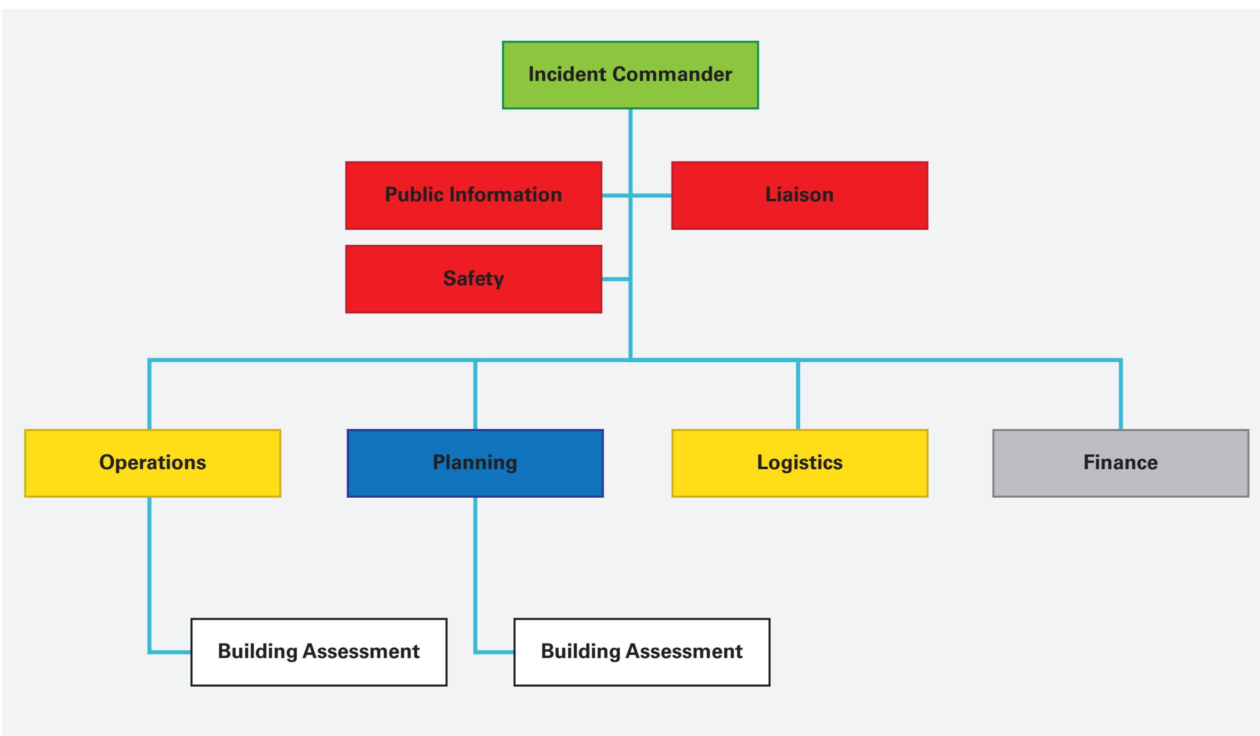


Figure 2. . Incident Command Structures with alternative locations for PDBA functions. Adapted from JIBC Incident Command Systems.

Note that in this model, PDBA may be logically located within either the Operations or the Planning sections. Over time, or alternatively, PDBA may be housed within the local government's existing building control/permitting infrastructure.

Several countries with ongoing seismic activity maintain dedicated building assessment units at a national level. For example, Italy maintains a comprehensive PDBA program, staffed with full-time engineers. In the Italian model, the program is established and run nationally, through the Department of Civil Protection, under the general framework of the National Service of Civil Protection. Operational activities are deployed regionally and municipally to specific response areas (crisis sites).

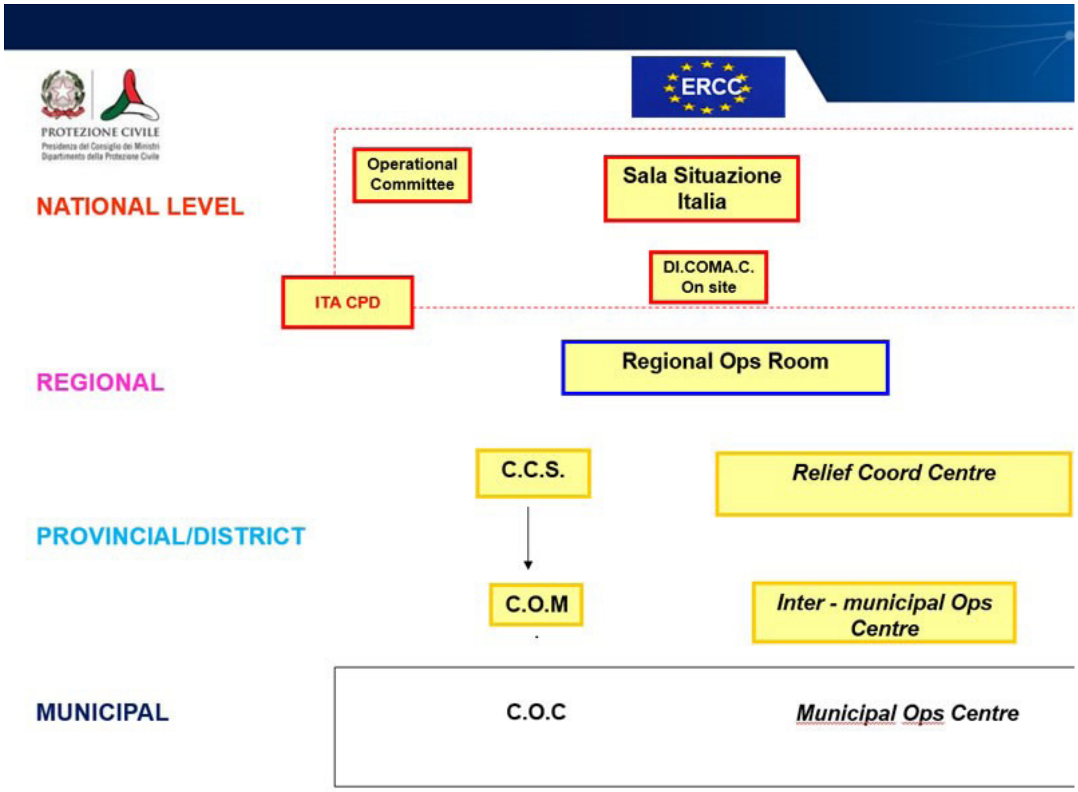


Figure 3. Source: Dolce, M. (2017). The 2016-17 Seismic Sequence of Central Italy: Main scientific features and technical emergency activities.

Similarly, Saito and Thakur (2012) describe the Japanese quick risk inspection process as functioning at the local government level, supported by disaster countermeasure office at the prefecture level of government.

Figure 4. Source: Saito, T., & Thakur, S. K. (2012), p. 5.

1.2 ADMINISTRATION

ROLES AND RESPONSIBILITIES FOR PDBA PERSONNEL

The following documents contain information and definitions of roles and responsibilities for PDBA personnel:

- BC Housing (2018). *Coordination of Damage Assessment.*
  - Safety Assessment Program Evaluator, p. 12.
  - Building Safety & Damage Assessment Program Coordinator, pp. 15 – 16
  - Building Damage Assessment Unit, pp. 17 – 18.
- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). *Field guide: Rapid post disaster building usability assessment: Earthquakes.*
  - Your rights and responsibilities, pp. 18 – 19. Includes information on both assessors' and building owners' rights and responsibilities.
- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). *Field guide: Rapid post disaster building usability assessment: Flooding.*
  - Your rights and responsibilities, pp. 16 – 17. Includes information on both assessors' and building owners' rights and responsibilities.
- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). *Field guide: Rapid post disaster building usability assessment - Geotechnical.*
  - Geotechnical role, pp. 9 – 10. Includes information on both coordination and assessor roles and responsibilities.
- New Zealand Society for Earthquake Engineering (2009). Building Safety Evaluation during a State of Emergency: Guidelines for Territorial Authorities.
  - This document was a precursor to the now-existing New Zealand Building Assessment process and identifies anticipated roles and responsibilities for key stakeholders and participants.
  - Building Safety Evaluation Leader Responsibilities, p. 21.
  - Support Staff, p. 21.
  - Sector Coordinators, p. 21.
  - Induction and Technical Coordinator, p. 21.
  - Rapid Assessment Inspectors, p. 22.

3.2 Key Roles

The following table identifies the key roles and primary source of resources envisaged for the Building Safety Evaluation process.

Role	Primary Source of Resources
Building Safety Evaluation Leader	Territorial Authority (Senior Building Control personnel)
Support Staff	Territorial Authority
Sector Co-ordinators	Territorial Authority (Senior Building Control personnel)
Induction & Technical Co-ordinator	Structural engineers
Rapid Assessment Inspectors: *Level 1 Rapid Assessment*	Volunteer professional structural engineers, Territorial Authority building control staff, architects and other Licensed Building Practitioners
Level 2 Rapid Assessment	Volunteer professional structural, building services and geotechnical engineers Heritage professionals
Detailed Engineering Evaluation Inspectors	Contracted Professional Engineers

Figure 5. Source: New Zealand Society for Earthquake Engineering (2009), p. 19.

- Baggio, et al. (2007). Field Manual for past-earthquake damage and safety assessment and short term countermeasures (AeDES).
  - 1.3 Emergency management and surveyor's responsibility, pp. 14 – 15.
- Federal Emergency Management Agency (2016). Damage assessment operations manual: A Guide to assessing damage and impact.

  Appendix A: Roles and Responsibilities:
  - Local or County Damage Assessment coordinator
  - Damage Assessment Team Member
  - Tribal Government Damage Assessment Coordinator
  - Sate or Tribal Government PA Damage Assessment Team Leader
  - Sate or Tribal Government PA Damage Assessment Team Member
  - State or Tribal IA Damage Assessment Team Lead
  - State or Tribal Government IA Damage Assessment Team Member
  - State or Tribal Government Voluntary Agency Liaison
  - State or Tribal Government Mass Care and Emergency Assistance Crew Lead
  - FEMA PDA Coordinator
  - FEMA PA PDA Team Lead
  - FEMA PA PDA Team Member
  - EMA IA PDA Team Lead
  - FEMA IA PDA Team Member
  - FEMA Voluntary Agency Liaison
  - FEMA Mass Care and Emergency Assistance Crew Lead

- Ghilarducci, M. (2015). Post-Disaster Safety Assessment Program: Guideline to the activation and utilization of program resources.
    - The California SAP guidelines provide a useful diagram, comparing responsibilities of key personnel in a PDBA system.

Figure 6. Source: Ghilarducci, M. (2015). *Post-Disaster Safety Assessment Program: Guideline to the activation and utilization of program resources,* p. 8.

- Information is provided on the responsibilities of the following personnel:
    - SAP Evaluator: Responsibilities, p. 8.
    - SAP Coordinator Responsibilities, p. 12.
    - Statewide SAP Coordinator Responsibilities, p. 13.

ADMINISTRATION STRUCTURES

The following figure outlines the New Zealand Ministry of Business, Innovation, and Employment Rapid Building Assessment process organizational Structure.

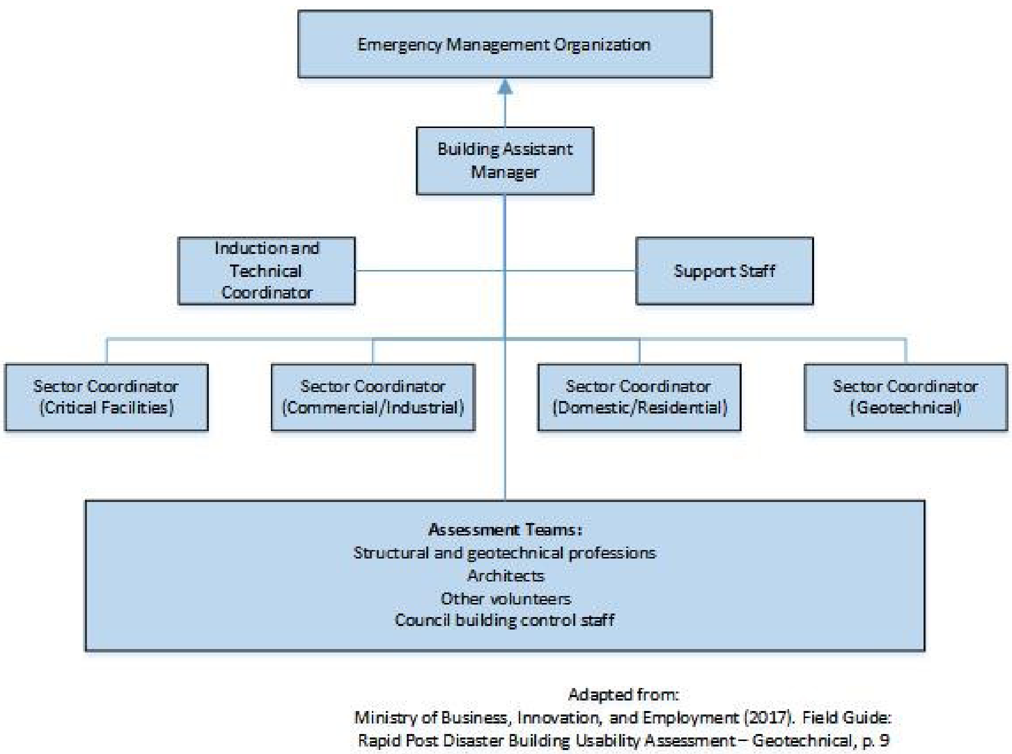


Figure 7. PDBA Administrative Structure, MBIE, New Zealand.

Note that, in this model, separate "Sectors" may be set up to deal with specific types of PDBA needs. For example, Sectors may be assigned by geographic area (e.g., the downtown business core; suburban areas), by building type (as in the example above, there are sectors for critical infrastructure, commercial, domestic buildings, etc.), or for specialty situations (e.g., geotechnical assessment, if required).

Individual communities may set up functional organizations to meet local needs and resources. The example below is a generic model based on discussions with several communities that conducted PDBA operations.

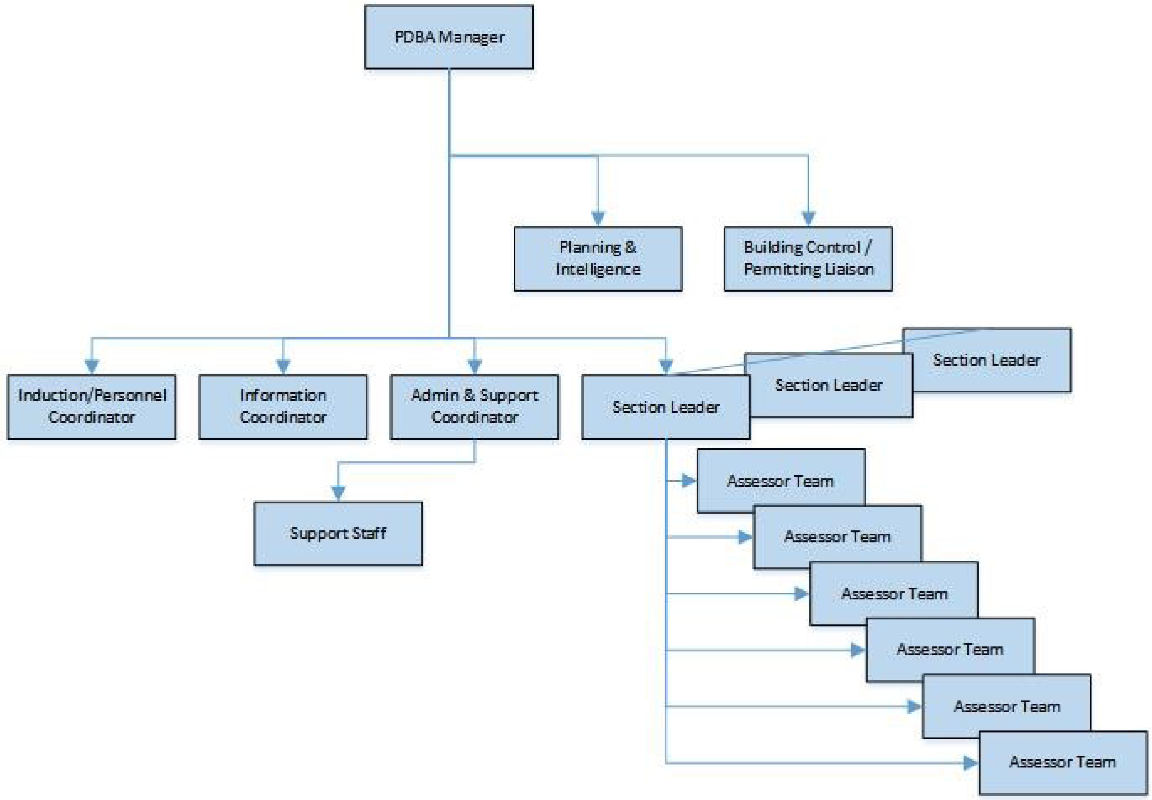


Figure 8. Generic PDBA Administrative Structure.

In this model, the Planning & Intelligence and Building Control/Permitting Liaison link out to EOC and/or local government building/permitting functions. The Induction/Personnel coordinator establishes and maintains rosters of personnel. The Information Coordinator handles incoming reports and documentation, and links to broader EOC/Emergency Operations information systems. Both Support Staff and Section Leader/Assessor teams would expand as required over time based on needs and availability of resources.

The California Safety Assessment Program identifies multiple levels of authority and response.

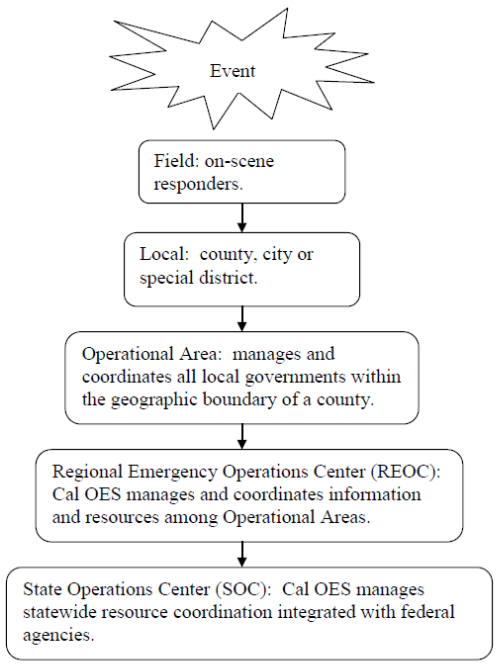


Figure 9. Source: Ghilarducci, M. (2015). *Post-Disaster Safety Assessment Program: Guideline to the activation and utilization of program resources,* p. 14

Saito and Thakur (2012) describe the structure of quick risk inspection groups at the local government level in Japan.

Figure 10. Source: Saito & Kumar (2012), p. 6.

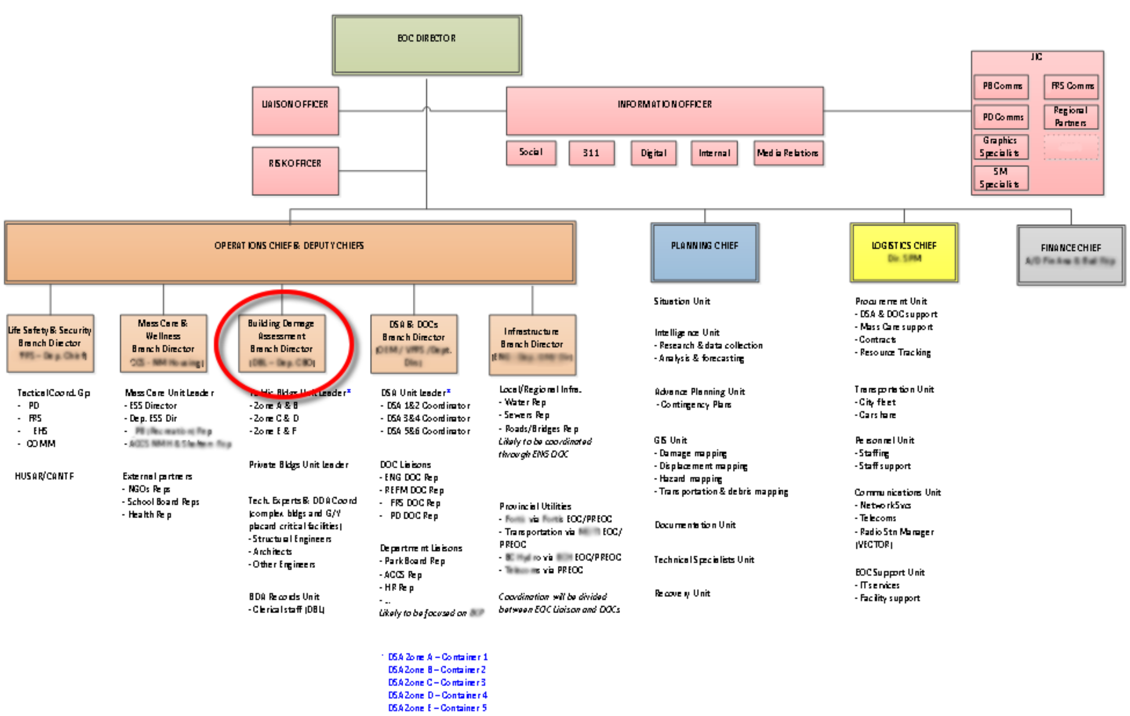


Figure 11. Source: Sample Municipal Administration Structure.

1.3 SITUATIONAL AWARENESS

DEVELOPING SITUATIONAL AWARENESS

There is little documentation or discussion in the literature on the actual operations and decision-making in post disaster building assessment. Much of the professional documentation sets out operational structures and describes procedures for assessing individual buildings. Little has been written describing how to establish an overall PDBA process, how to set and meet priorities, and how to develop situational awareness. Several participants in New Zealand interviews noted that much of the “expertise” at the operational level is situational. Many of the strategies that were effective in urban and suburban Christchurch were not applicable to PDBA operations in rural Kaikoura. Similarly, much of central Christchurch was severely damaged and the local government was able to close off and evacuate the entire area. Assessors then cleared sections of the cordoned off areas over time. This strategy was quite effective in the Christchurch context. However, local government planners in Wellington were unable to employ a similar strategy as damage in their central core was more diffuse – many buildings had minimal or no damage, while others suffered significant damage. Additionally, Wellington’s core had a more diverse mix of residential and commercial structures, making it more difficult to consider cordoning off and restricting access to large parts of the city while building assessment was conducted.

The Rapid Impact Assessment resource from CDEM (New Zealand) does provide a flowchart that may be useful in identifying a process for developing overall PDBA situational awareness.

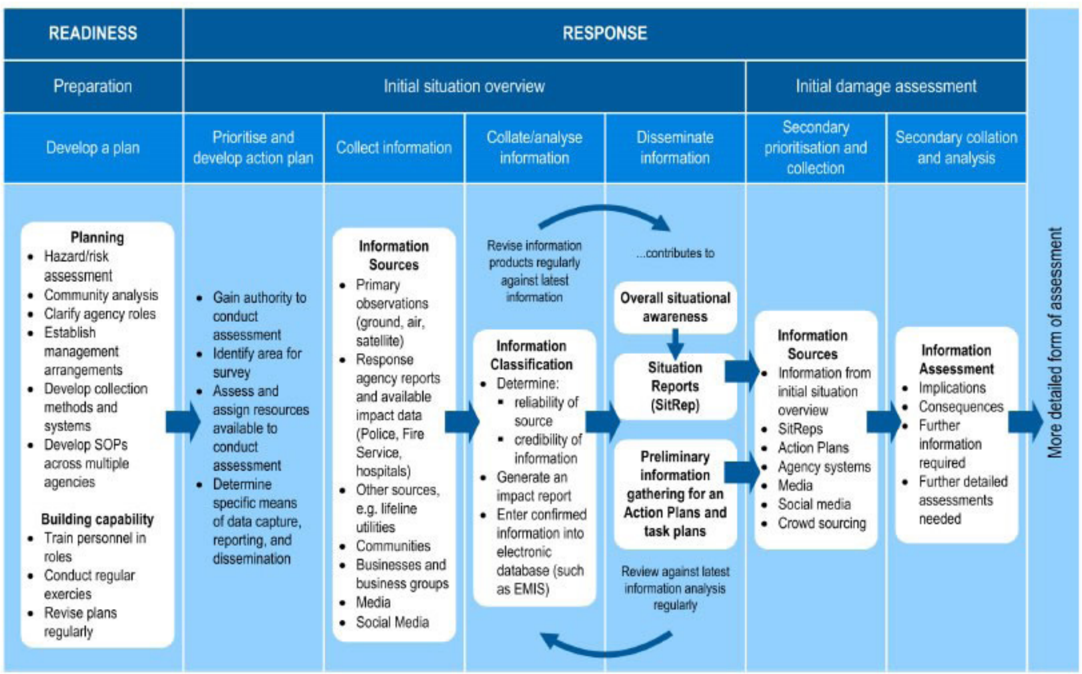


Figure 1 Overview of the two types of rapid impact assessment

Figure 12. Source: Ministry of Civil Defence & Emergency Management (CDEM) (2013). Rapid impact assessment: Information for the CDEM Section [IS 14/13], p. 9.

LEVERAGING PDBA AND OTHER EMERGENCY MANAGEMENT PROCESSES

New Zealand reported several instances of creative and cooperative activity between PDBA and other emergency response groups. In early days of the response, USAR personnel would consult with building assessment teams on potential issues with complex structures. In rural areas, search and rescue and fire personnel accompanied damage assessment teams to provide short term countermeasures (e.g., toppling unstable chimneys in simple residential buildings) that allowed continued occupation of the buildings. CDEM and local government personnel also described having social services personnel accompany PDBA teams in suburban residential areas to provide information and support to homeowners.

Note that each of these examples was effective within specific sets of circumstances, and that participants also described that the examples weren't necessarily transferable to other situations. While embedding social services personnel was effective in relatively dense suburban areas, it was less effective in rural areas. In residential areas, the PDBA and social services teams could work relatively independently within an area (say a one or two block radius), then meet up at designated times. In rural areas, homes and properties were more spread out and teams had to drive between residences. This resulted in one team or another often waiting for the other team to finish before both teams could travel to the next property.

It is also important to recognize that both overall response and PDBA processes change over time, as do the number and type of resources available to conduct operations. PDBA personnel should work with other emergency management and local government personnel on an ongoing basis to explore options and opportunities for leveraging resources.

INDICATOR BUILDINGS

Aftershocks may cause significant and new damage to buildings. The need to re-assess every building which had already been assessed following the primary earthquake can overwhelm available PDBA resources and cause unmanageable delays.

One potential solution to the problem of having to re-assess every building is the use of "indicator buildings." Indicator buildings are exemplar buildings, representative of specific building designs and construction within an affected area. These indicator building reflect structural similarities with similar buildings within a typology (e.g., S1 Steel Moment Frame – High Rise, more than 8 stories). Communities may identify indicator buildings for specific categories or building typologies. These building groupings should consider both construction typology (as above) and include geological conditions related to each construction typology (e.g., there may be a need for an indicator for a type of building that is near the coastline and for similar buildings that are built inland on bedrock).

Following an event, the community monitors these indicator buildings. After subsequent events, such as aftershocks, the indicator buildings are re-evaluated. If the indicator buildings experience new damage in the aftershock, it is recommended that other similar buildings in the affected area be re-inspected. In the event that an indicator building sustained significant additional damage during an aftershock, or showed signs of movement, all buildings of that construction type would be re-inspected.

Resources

- New Zealand Society for Earthquake Engineering (2011). Building Safety Evaluation Following the Canterbury Earthquakes.
    - The Indicator Building procedure that had its genesis after the September earthquake was expanded and formalised. This procedure involves identifying a set of buildings to specifically check following significant aftershocks to gauge the extent of further damage (if any). This provides a rational decision making tool to determine whether to continue with the building assessment programme as planned, or revisit or re-start building safety evaluations. This proved invaluable in safe and efficient use of resources for re-assessing particularly the CBD building stock after each of the significant aftershocks. It also encouraged the management team to increase the rigour of the welfare checking process of deployed teams. (p. 29)

Additional information on the concept of indicator buildings can be found in the following resources:

- Gallagher, R., Lizundia, B., & Barnes, J. C. (2011). Building Safety Evaluation after the February 22, 2011 Christchurch, New Zealand Earthquake: Observations by the ATC Reconnaissance Team.
- Lizundia, B., Hortacsu, A., & Gallagher, R. (2017). Improvements in postearthquake building safety evaluations: lessons learned from recent earthquakes.
- Moon, L. M., Griffith, M. C., Ingham, J. M., & Biggs, D. T. (2012, September). Review of transect of Christchurch CBD following 22 February 2011 earthquake.
- Murty, C. V. R., Rai, D. C., Kumar, H., Bose, A. K., Kaushik, H. B., Jaiswal, A., & Kumar, R. P. (2012). A Methodology for documenting Housing Typologies in the Moderate-Severe Seismic Zones.
- Wieland, M., Pittore, M., Parolai, S., Begaliev, U., Yasunov, P., Niyazov, J., ... & Abakanov, T. (2015). Towards a cross-border exposure model for the Earthquake Model Central Asia.

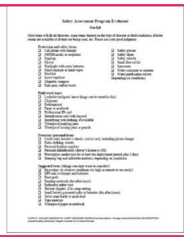
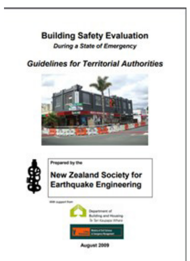
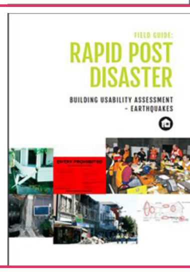
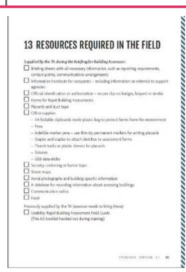
1.4 OPERATIONS

TEAM EQUIPMENT AND RESOURCE LISTS.

The following resources have examples of team equipment and resource lists:

BC Housing (2017). *Field manual: Rapid Damage Assessment. BC Housing:*

- Personal Safety and Equipment, pp. 5 – 6.

	BC Housing (2018). *Coordination of Damage Assessment Handout.* • Go Kit for Safety Assessment Program Evaluator, p. 13. • Building Safety & Damage Assessment Program Coordinator, RESOURCES REQUIRED, p. 16. • Emergency Operations Centre, Tools and Resources, p. 18.
	New Zealand Society for Earthquake Engineering (2009). *Building Safety Evaluation During a State of Emergency: Guidelines for Territorial Authorities.* • Pre-planning and Maintenance Checklists, p. 30. • Appendix D: List of Essential Items to be Provided to Assessment Teams, p. 42.
	New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). *Field guide: Rapid post disaster building usability assessment - Earthquakes.* • Resources required in the Field, pp. 81 – 82.
	New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). *Field guide: Rapid post disaster building usability assessment - Flooding.* • Resources Required in the Field, pp. 65 – 66.
	New Zealand Ministry of Business, Innovation and Employment (MBIE) (2017). *Field guide: Rapid post disaster building usability assessment - Geotechnical.* • Safety Equipment, p. 30. • Useful Resources for Field Work, p. 31.

LEVERAGING PDBA AND OTHER EMERGENCY MANAGEMENT PROCESSES

New Zealand has successfully employed mixed-function teams within specific situations to address multiple needs. As noted in the previous section, damage assessment personnel may work with USAR and rescue teams to provide expertise and advice (note that damage assessment personnel did not directly participate in evacuation or rescue efforts). USAR personnel were used in rural areas to perform short term countermeasures such as pulling down unstable chimneys, allowing residents to stay in their homes. Similarly, teams in residential areas included social service (welfare) personnel who were able to provide support to residents. New Zealand also reported embedding geotechnical engineers in damage assessment teams, as well as including welfare/social services personnel with teams (see following section for references).

STRATEGIES FOR FORMING PDBA ASSESSMENT TEAMS

PDBA assessment teams are the functional unit of PDBA operations. In general, teams conducting exterior assessments of non-complex residential structures should consist of a team leader who has the authority and expertise to sign placards and assessment forms, and a minimum of one other assessor. Teams that will conduct interior and exterior assessments should consist of a minimum of three assessors, one of whom remains outside during the interior inspection.

Please refer to the BC PDBA Framework and Recommendations, Appendix 2, PDBA Assessment matrix. This matrix is an example of a community-level process for identifying the mix of assessors required for specific types of buildings in a community.

Recommendations for team composition vary across systems, as indicated below:

- BC Housing (2017). *Field manual: Rapid Damage Assessment*.
    - Rapid Damage Assessment Teams need to be based on those who have taken rapid damage assessment training. In addition to the basic team of two persons, it may appropriate to include:
        - Emergency Social Services (ESS) personnel
        - Officials from the utilities e.g. electricity, gas
        - Health services officials
        - Fire Department personnel
        - BC Safety Authority Officers, p. 6.
    - There should be one DA coordinator for every 7 assessment teams, p. 58.
- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). *Field guide: Rapid post disaster building usability assessment - Earthquakes.*
    - Assessors should always work in teams, and their movements should be tracked for safety reasons. Each assessment team ideally consists of two technical field staff and a person to interact with the occupants (this may be a non-technical person). For assessing large commercial buildings, a CPEng registered engineer must be a member of the technical staff. p. 9.
    - Designate a safety person (if you work in a team of three) to remain outside the building to raise the alarm if necessary. p. 12.
- Note that these recommendations are mirrored in the New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014) *Field guide: Rapid post disaster building usability assessment - Flooding.*
- Applied Technology Council (1989). *ATC 20: Procedures for postearthquake safety evaluation of buildings.*
    - …The procedure calls for an initial Rapid Evaluation of each building selected for inspection. This normally the first level of evaluation and is designed to quickly designate the apparently safe and the obviously unsafe structures. Those not specifically designated, the so-called gray area structures, are then designated for a more detailed visual examination by a structural engineer… After this evaluation, any further evaluations would normally be done by a structural engineer consultant retained by the owner to prepare an Engineering Evaluation of the structure. p. 13.

TECHNIQUE	REQUIRED PERSONNEL
Rapid Evaluation	Qualified building inspectors Civil/Structural engineers Architects Other individuals deemed qualified by local jurisdiction
Detailed Evaluation	Structural engineers
Engineering Evaluation	Structural engineering consultant

Adapted from Table 3.1 *ATC-20 Building Evaluation Techniques*, p. 15.

- ❍ It has been the experience to date in California that most initial postevent inspections are done by building inspectors from the local building department or from nearby communities… Rapid Evaluation is designed to utilize the talents and experience of building inspectors and other people with similar experience in construction. This does not, of course, preclude the possibility of using experienced structural engineers, architects, etc. to do initial evaluations. p. 19.
- ❍ The Rapid Evaluation method is designed for use by individuals with at least 5 years of experience in general building design, construction, or inspection. This includes building inspectors in particular as well as volunteer civil/structural engineers, architects, building contractors, and others who have been involved in the building design and construction process. p. 19.
- ❍ Detailed Evaluation Method…. This method is primarily used to evaluate the safety of buildings posted Limited Entry after a Rapid Evaluation. Normally this will be done by having engineers familiar with building design observe the damage and assess its impact on life safety. Ideally, this evaluation will be carried out by a team of at least two structural engineers, both of whom have experience in the seismic design of buildings similar to those being inspected. In the aftermath of a large quake, however, this ideal may be impossible, and alternative teams will probably have to be used. One such alternative is the use of a team consisting of one structural engineer and one building inspector. p. 25.
- ❍ An "ideal" survey team might include a building official who knows the community thoroughly, and a structural engineer with practical experience in all kinds of construction. Under emergency circumstances, however, the survey might be done by firefighters or police officers observing building damage conditions as they respond to other specific emergencies… Normally, structural engineers, structural plan checkers, and other engineers with structural design expertise will be excellent choices for this task. Additional desirable qualifications include 5 to 10 years or more of experience, previous postevent inspection experience, and knowledge of earthquake effects on buildings. p. 22.
- ❍ Certain items of concern are probably best evaluated by specialists. For example, a reinforced concrete highrise with substantial cracking in frames or walls is probably best visually assessed by a team of structural engineers experienced in the design of such structures. Similarly, suspected geotechnical hazards need to be assessed by geotechnical engineers or geologists, and elevator safety question s by elevator engineers and specialists. The makeup of the damage inspection team for the Detailed Evaluation of either a single large building or an area of several questionably damaged buildings needs attention from those coordinating and directing the overall effort. p. 25.

- Applied Technology Council (1995). ATC 20-s: Addendum to the *ATC-20 postearthquake safety evaluation procedures*.
  - ❍ An "ideal" survey team might include a building official who knows the community thoroughly, and a structural engineer with practical experience in all kinds of construction. Under emergency circumstances, however, the survey might be done by firefighters or police officers observing building damage conditions as they respond to other specific emergencies. p. 22.

Several documents in the literature review included information on team composition:

- Goretti, A., & Di Pasquale, G. (2002, September). An overview of post-earthquake damage assessment in Italy. In *EERI invitational workshop. An action plan to develop earthquake damage and loss data protocols, California.*

    Goretti and Di Pasquale surveyed multiple damage assessment processes in an article from 2002. The following are their findings regarding team composition:

    - Cyprus: Each survey team is typically composed of 2 people, which may be engineers, architects or surveyors. p. 4.
    - Greece: Each survey team is typically composed of 2 people, with at least one of them being a structural engineer, if possible. Sometimes teams of 3 people are used, generally in case of re-inspection. Inspectors may be engineers, architects or surveyors. p. 5.
    - Italy: Each survey team is typically composed of 2 people, which may be engineers, architects or surveyors. p. 11.
    - Slovenia: Inspectors are either engineers or architects. Each survey team is composed of 3 or more inspectors: one is the leader, which is required to be trained and qualified for post-earthquake inspections and is either an engineer or an architect. The second person is for having a second opinion; he may have only a high school degree. In case of strong earthquake, he may have not been trained. The third person in a team is from local authorities and is in charge of taking photos, bringing light and hammer and so on. p. 21.
    - Spain: Each survey team is composed typically of two people. Inspectors are usually architects… p. 27.
    - Turkey: Each survey team is usually composed of two people. Inspectors can be either engineers, architects or undergraduates holding a technical diploma. p. 13.

- Dolce, M., & Goretti, A. (2015). *Building damage assessment after the 2009 Abruzzi earthquake.*
    - The inspector's teams were made up of two or three experts from Italian Regions, Provincial and Municipal technical offices, Fire Brigades, Universities coordinated by the Network of University Earthquake Engineering Laboratories, the National Chambers of Engineers, Architects and Surveyors, European Centre for Training and Research in Earthquake Engineering and the National Research Council. (p. 2242)
    - Also in the case of the 2012 Emilia earthquake, a huge effort was made to organize the damage and usability assessment survey. The assessment was actually performed by experts coming from different Regions and from the National Fire Brigades, by researchers of the DPC Centres of Competence (ReLUIS and EUCENTRE), and by engineers, architects and surveyors coordinated through the related national professional Councils… p. 2244.

- Gallagher, R., Lizundia, B., & Barnes, J. C. (2011). *Building Safety Evaluation after the February 22, 2011 Christchurch, New Zealand Earthquake: Observations by the ATC Reconnaissance Team.*
    - In discussions with Christchurch officials, it was learned that a typical safety evaluation "team" for houses and residential buildings might consist of four people: one safety evaluator, two "welfare" staff (e.g., members of a non-governmental organization such as the Red Cross), and a driver. The consensus of those individuals interviewed was that the addition of the two welfare staff, while of aid to the occupants, significantly slowed the building safety evaluation process and is generally not desirable. p. 43.

- New Zealand Society for Earthquake Engineering (2011). *Building Safety Evaluation Following the Canterbury Earthquakes.*
    - Assessment teams were organised to comprise structural and/or geotechnical engineers and Christchurch City Council building control personnel (or Council's Response Team members). Council personnel were warranted to place the placards on buildings, following agreement by the teams. NZ USAR Rescue Technicians were also added in due to their availability, and this enabled teams of a minimum of three persons to be created. The number of teams deployed into the CBD was

limited to 29 by the availability of engineers. 23 of these teams were tasked with Level 1 (exterior) assessments, and allocated to identified blocks of the CBD. The remaining teams were tasked with Level 2 assessments of buildings already identified as requiring a more detailed assessment, and with interior access available. These five- person teams were assigned two engineers and two Council personnel along with a USAR Rescue Technician. p. 16.

- ❍ A team comprised of senior inspectors and an engineer looked at large public buildings that were likely to be needed for accommodating large numbers of people evacuated from damaged housing - schools, halls with commercial kitchens, and other halls. p. 23.

From Key Informants

In addition, participants in the interviews and site visit addressed team composition:

- [These are the] are the guidelines we should be giving – teams can't be static – need to match the needs of the particular situation. AG011 Reference 2, 1.
- When these rapid assessments are done, building inspector assessors are not necessarily engineers – that's the risk; residential wise, [non-engineering] assessors are pretty good; beyond timber frame, you need people who are really familiar with commercial construction. The risk in single story wood frame construction is different from commercial structures. AG011 Reference 1, 1.
- Question: Did engineers get involved in residential buildings? Answer: Mostly, it was building inspectors… that was a better use of their expertise. AG011 Reference 2, 1.
- [In the rural setting], a lot of streets didn't need geotechs, but [for properties] on the cliffs, needed a different approach…. We did bring the specialists in… one group came through to do an [building] assessment, then a geo tech comes through as well. AG010 Reference 1, 2.
- Challenging in that different times required different groups. Sometimes we'd put two or three welfare people on the teams if they were going to take longer than the structural engineers: 1 geo tech, 1 building inspector, 3 welfare people – varies to meet the needs of the particular areas. AG010 Reference 1, 3.
- Teams often consisted of two technical assessors (ideally, at least one was an engineer), with one Emergency Social Services / Welfare support person. Some had a psychosocial member from the health authority AG005 Reference 1, 4.
- Notes from Expert Working Group review:
    - ❍ Always at least 2 on a team for safety
    - ❍ Even in school if facilities manager doing assessment, take someone along
    - ❍ Basic vs ideal numbers – need to be flexible
    - ❍ Take Emergency Social Services personnel along when you can
    - ❍ 2 for peer review, check
    - ❍ If exterior, two enough, but if going inside, need 3 – one to stay outside
    - ❍ Complex buildings may take larger teams – how big? What expertise?
    - ❍ # depend on scale, context of event
        - ❍ AG005 Reference 9, 3

DEVELOPING PDBA ASSESSMENT STRATEGIES.

The research team found a gap in formal documentation or processes for developing overall PDBA strategies – e.g., what areas to assess first, how to develop priorities, how to best match available resources with emerging needs.

One of the difficulties in documenting "generic" strategies is the wide variability in potential hazards, actual events, extent and type of building stock, availability of personnel and resources, and experience of operational and administrative personnel. In practice, strategies are shaped by a variety of factors which make it difficult to directly apply principles from one event to another. In the 2011 Christchurch earthquake, a large portion of the downtown business core was heavily damaged. This area was cordoned off and a group formed to systematically work through the area with the goal of gradually reducing the cordon. However, this strategy would not make sense in rural and suburban districts. Similarly, participants in the Wellington interviews noted that the CDB in Christchurch had limited residential building stock; Wellington has a much greater mix of building types in its core, and the cordoning strategy would not likely be effective for their area.

Thus, the recommendations in the PDBA Framework document emphasize the need for both pre-planning based on local needs and resources and adaptation during an actual event.

The following comments are extracted from several documents and from interviews and workshops with key informants in the study.

PDBA Programs and Field Guides

- Applied Technology Council (1989). ATC 20: Procedures for postearthquake safety evaluation of buildings.
    - Immediately following a damaging earthquake, local building departments are usually swamped by the task of making building safety evaluations. Even with an influx of assistance from outside sources, including volunteers, there is normally much more work that must be completed within a short period of time than can be handled by available staff. Procedures for the safety evaluation of buildings need to account for this and recognize that trained, experienced manpower to do inspections will likely be in short supply. Normal procedures involve an initial reconnaissance by police and fire department personnel, followed by visits to the hardest-hit areas by building department personnel. p. 13.
- New Zealand Society for Earthquake Engineering (2011). Building Safety Evaluation Following the Canterbury Earthquakes.
    - In addition to the above, a limited pool of specialist engineers was provided to two building control operations. These two operations covered the extensive evaluation of suburban residential dwellings (Operation Suburb, deploying up to 1,000 building control officials, welfare representatives and EQC personnel per day) and suburban commercial buildings (Operation Shop). A team of engineers that could respond rapidly to urgent incoming requests for building inspections was also established, and included geotechnical engineers as well as structural engineers. p. 28.

From Key Informants

Participants in the study described a number of strategies for prioritizing areas, matching assessment teams to area needs, and managing workflow. Initial efforts are often aimed at ensuring critical infrastructure and hardest hit areas receive initial attention. Various strategies can then be developed to guide ongoing PDBA processes.

Potential strategies include assigning groups to:

- work within geographic or municipal regions
    - e.g., have teams with sufficient structural engineering and experience in the design of complex buildings tasked to working in a central business/commercial district, while teams with building inspectors supported by engineers assess residential buildings in suburban and rural districts
- target teams to specific building types
    - e.g., deal with critical infrastructure first, then dedicated groups for complex buildings, commercial structures, residential buildings, etc..
- dedicate assessment teams to specific types of resources
    - e.g., clearing grocery and pharmacy buildings (a strategy employed in Christchurch)

BRIEFING AND DEBRIEFING PROCESSES AND FORMS.

Resources

The following documents contain information, items to consider, and checklists for briefing and debriefing processes:

- BC Housing (2017). *Field manual: Rapid Damage Assessment.*
    - Deployment Checklist, pp. 58 - 60
- Applied Technology Council (1995). *ATC 20-s: Addendum to the ATC-20 postearthquake safety evaluation procedures.*
    - 3.2.4 Survey Debriefing, p. 25
- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). F*ield guide: Rapid post disaster building usability assessment - Earthquakes.*
    - Debriefing, p. 37

- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). *Field guide: Rapid post disaster building usability assessment - Flooding.*
    - Debriefing, p. 35
- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2017). *Field guide: Rapid post disaster building usability assessment - Geotechnical.*
    - Deployment and Briefing, pp. 11 - 12.

Sample content for Briefings

- California Emergency Management Agency (2012). State of California Safety Assessment Program Coordinator Student Manual.

  The morning briefing will review at least the following:
    - Accounting for all SAP evaluators.
    - Safety issues are reviewed.
    - Situation status of the disaster and the SAP response progress are reviewed, including status of monitor buildings.
    - Action plan objectives for the next 24 hour period, with a review of long-term objectives.
    - Review of assignments and new assignments.
    - Brief questions from SAP evaluators.

  p. 45

  A daily debriefing might cover the following:
    - Review of the Rapid Assessment or Detailed Assessment forms.
    - Discussion of any questions or safety issues that came up through the day.

  p. 47
- Ministry of Civil Defence & Emergency Management (CDEM) (2013). Director's guideline for CDEM Group and Local Controllers [DGL06/08].
    - While this document is geared towards area Controllers, the section on Stakeholder Briefings includes guidelines on structure and content for briefings with external stakeholders and groups. See p. 50, 74.

- BC PDBA Framework and Recommendations

  Daily briefings should include:
    - Overall status of PDBA activities
    - Current priorities and deployment strategies
    - Findings and issues from previous day's assessments and other EM activity
    - Issues and trends noted in recent assessments
    - Lists of areas and/or specific buildings to be assessed for the day
    - Known or suspected risks to personnel
    - Intelligence or background information available to teams about their assignments (e.g., plans, drawings, reports from other EM processes and assessments)
    - Opportunities for teams/personnel to provide input, raise concerns or questions, make suggestions, etc.

  Daily debriefings should include:
    - Review of day's PDBA activities
    - Summaries of findings and issues from day's assessments and other EM activity
    - Emergent issues or concerns
    - Lists of areas and/or specific buildings that were assessed during the day

- ❍ Intelligence or background information that should be passed to EOC and other stakeholders
- ❍ Opportunities for teams/personnel to provide input, raise concerns or questions, make suggestions, etc.

Individual team or group or area teams should conduct daily end-of-day meetings which should include:

- ❍ Review of day's activities
- ❍ Identification of issues, challenges, or information to be passed back to operations and EOC
- ❍ Equipment, communications, or logistics concerns
- ❍ Assessment findings and documentation
- ❍ Opportunities to discuss any psychosocial impacts or needs

PROPPING, SHORING, AND SHORT-TERM COUNTERMEASURES

Propping and shoring are not part of Post Disaster Building Assessment processes; however, participants from multiple programs emphasized the importance of establishing and preparing for this function.

Some systems, such as Italy, have dedicated units designated for propping, shoring, and short-term countermeasures. The MATILDA project (see https://projmatilda.wordpress.com/2016/01/05/92/) was a multi-country initiative in Europe which developed "modules" or specialized teams to perform basic structural assessment (BSA), advanced structural assessment (ASA), and to provide short-term countermeasures (STC). According to Ponticelli (2017), the goals of the STC team were to provide:

- Shoring for life rescue
- Shoring for building preservation (e.g., strategic and heritage buildings)
- Advising and training for local groups
- Tactical and operational advice to LEMA/Response teams.

Some additional information on short term countermeasures is available in the Field Manual for post-earthquake damage assessment and short term countermeasures (AeDES) (Baggio et al., 2007). Participants from New Zealand noted that over 10 kilometers of fencing were brought in to Christchurch and that responders employed a variety of innovative techniques for stabilizing and securing buildings, such as the use of shipping containers to prop up unstable buildings.

Some general comments on cordoning, propping, and shoring can be found in:

- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). *Field guide: Rapid post disaster building usability assessment - Earthquakes*, p. 35.
- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). *Field guide: Rapid post disaster building usability assessment - Flooding*, p. 33.
- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2017). *Field guide: Rapid post disaster building usability assessment - Geotechnical*, p. 6.

The use of propping, shoring, and short-term countermeasures has been identified as an area requiring further research.

1.5 INFORMATION MANAGEMENT

Please refer to Section 2. PDBA Forms and Reports for lists and links of PDBA forms, checklists, and resources.

USE OF TECHNOLOGY IN PDBA OPERATIONS.

Using technology to plan for and report PDBA can play an extremely important role in providing real time situational awareness, reducing labour requirements during the emergency, and reducing the risks of errors or duplication related to situational awareness.

Immediately following an earthquake, technology can help to pinpoint areas which require building assessments through the use of shake-maps developed from strong motion detectors, or from images captured by unmanned aerial vehicles (UAV's). Buildings of high importance can also be equipped with devices that detect the level of damage they experience following an earthquake, and then automatically report the anticipated level of damage experienced by the building in real time. Examples of shake map use developed from strong motion detectors can be viewed on the BC Ministry of Transportation and Infrastructure website at http://www.bcsims.ca/.

During the PDBA process, assessors working in the field can utilize electronic geodatabase technology to map and record building conditions. Recording data can occur more quickly on mobile applications than on paper, which helps to reduce the risk of errors and avoid the need to recapture data after it has been turned in by assessors to an EOC at the end of their shift. Instead, assessors can log into GIS software such as the Collector for ArcGIS app, and complete the forms on a handheld smart device. In locations with cellular service, their assessment data can be reviewed and acted upon in real time at an EOC. GIS technology has been successfully utilized in British Columbia following the provincial freshet flooding in 2018, and is available through BC Housing's Rapid Damage Assessment website at http://bchousing.maps.arcgis.com/home/item.html?id=688a90722aec44d1a30b4ee77209b600.

Information on the use of technology in PDBA can be accessed in the following resources:

- Federal Emergency Management Agency (2016). *Damage assessment operations manual: A Guide to assessing damage and impact.*
    - Integration of Geospatial Analysis and Technology, pp. 74 – 78.
    - Integration of Mobile Technology, p. 79
- Additional References:
- Seismic Network - http://www.oceannetworks.ca/innovation-centre/smart-ocean-systems/earthquake-early-warning
- Building Instrumentation - https://www.eeri.org/wp-content/uploads/4640.pdf

1.6 ASSESSMENT TEAMS

NOTIFICATION AND DEPLOYMENT PROCESSES

Notification and Deployment processes may be set up at a national or local level.

Countries such as Italy and Greece have dedicated national programs including assessors on staff. This model is viable in regions with high, ongoing risks associated with hazards such as earthquake and flooding.

In other countries, PDBA is managed at a local level. PDBA in New Zealand is set up at local levels, supported by national infrastructure and resources. Several communities in New Zealand have robust processes, documents, and forms to support local deployment, supported by national level Civil Defence and Ministry of Business, Innovation, and Employment programs.

PDBA occurs at the local government level in British Columbia, supported by overarching emergency management programs and agencies at the provincial level. Several BC communities have PDBA systems in development or in place. BC Housing also has resources that can be used at the community level, including pre-deployment checklists (see Section 2, Forms and Checklists, further in this document).

The Post-Disaster Safety Assessment Program: Guideline to the activation and utilization of program resources manual (2015) describes the activation process the state of California Safety Assessment Program.
Ideally, communities should have preplanned processes for identifying local/regional PDBA personnel. In addition, there should be agreements in place at the regional and/or provincial level to bring in additional personnel as required.

ASSESSMENT TEAM RESOURCES AND CHECKLISTS

Please refer to Section 2, PDBA Forms and Resources further in this document.

FITNESS TO PRACTICE, HEALTH AND SAFETY

Safety, health, and fitness to practice are key concerns for PDBA and Emergency Management personnel. The increasing emphasis on these topics is evident in their inclusion in most PDBA resources. Information and resources to support the fitness to practice and wellness of assessment teams can be found in the following:

- BC Housing (2017). *Field manual: Rapid Damage Assessment.*
  - Personal Safety and Equipment, pp. 5 – 6.
  - Support to Occupants & Response Workers, pp. 61 – 62.
- BC Housing (2018). *Coordination of Damage Assessment Handout.*
  - Self-Assessment: Prior to Disaster Assignment
- Applied Technology Council (1989). *ATC 20: Procedures for postearthquake safety evaluation of buildings.*
  - Human Behaviour Following Earthquakes
  - Coping with Stress in the Field, pp. 113 - 114.
  - Providing Support to Inspectors in the Field, p. 114.
- Applied Technology Council (1995). *ATC 20-2: Addendum to the ATC-20 postearthquake safety evaluation procedures.*
  - Human Behaviour Following Earthquakes
  - Coping with Stress in the Field, pp. 63-64.
  - Providing Support to Inspectors in the Field, pp64 – 65.
- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). *Field guide: Rapid post disaster building usability assessment - Earthquakes.*
  - Dealing with People, pp. 83 – 85.
- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). *Field guide: Rapid post disaster building usability assessment - Flooding.*
  - Dealing with People, pp. 67 – 69.
- Ministry of Civil Defence & Emergency Management (CDEM) (2013). *Director's guideline for CDEM Group and Local Controllers [DGL06/08].*
  - Personal and Team Readiness, pp. 41-42.

COORDINATION WITH OTHER TEAMS

PDBA assessment teams are likely to overlap with various groups and teams involved in response and recovery. In the early phases of the response, PDBA teams may encounter Search and Rescue teams and other emergency response units. As the incident progresses, PDBA teams may encounter groups assessing infrastructure, geotechnical hazards, social service responders, assessors from property managers, building owners, and critical infrastructure agencies and organizations. PDBA managers should coordinate with other agencies and emergency management teams to ensure teams are aware of each other and to leverage resources when possible (e.g., having a social services member participate in PDBA teams in residential areas).

SAFETY PROCEDURES AND CHECKLISTS

Most PDBA Field Guides contain resources and information on both personal and team safety. Some specific resources include:

- BC Housing (2017). *Field manual: Rapid Damage Assessment.*
  - Personal Safety and Equipment, pp. 5 – 6.
- Applied Technology Council (1989). *ATC 20: Procedures for postearthquake safety evaluation of buildings.*
  - Field Safety for Engineers, pp. 114 – 118.
- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). *Field guide: Rapid post disaster building usability assessment - Earthquakes.*
  - Field Safety, pp. 10-14.
  - Simple First Aid Procedures, pp. 88-91.

- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). *Field guide: Rapid post disaster building usability assessment - Flooding.*
    - Field Safety, pp. 8-12.
    - Simple First Aid Procedures, pp. 32-35.
- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2017). *Field guide: Rapid post disaster building usability assessment - Geotechnical.*
    - Field Safety, pp. 29 – 30.
    - Simple First Aid Procedures, pp. 71-74.
- Ministry of Civil Defence & Emergency Management (CDEM) (2013). *Director's guideline for CDEM Group and Local Controllers [DGL06/08].*
    - Personal Preparedness Checklist, p. 108

1.7 BUILDING ASSESSMENT PROCEDURES

The heart of PDBA operations is the assessment of individual buildings. The research study examined PDBA practices from Australasia, North America, and Europe.

PDBA ASSESSMENT RESOURCES

Section 2 in this document contains descriptions of several PDBA programs, along with descriptions, links, and resources for PDBA assessment procedures, placard systems, forms and resources.

SAMPLE BUILDING TAXONOMIES

Local and provincial governments should be aware of the types of buildings that are found in their communities. These taxonomies may be based on factors such as size, construction material, construction type, building use, land characteristics, and complexity. Section 2, Building Taxonomies identifies systems and taxonomies that may be useful in classifying and categorizing a community's building stock.

PDBA BUILDING ASSESSMENT MATRIX

The PDBA Building Assessment Matrix, found in Appendix 2 of the *BC PDBA Framework and Recommendations* document, provides a tool for assisting communities to match the skills, credentials, and backgrounds required to perform building assessment for common types of buildings within their community.

The sample matrix provides a template for communities to identify the types of buildings in their community, the types of assessors who are available to perform PDBA, and the composition of assessor teams required for different types of buildings.

The sample is provided only as an example and starting point for a community and should not be used without expert consultation and adaptation to the community's specific building stock and availability of assessors.

1.8 BUILDING STATUS

The concept of "building status" emerged as the current status of a building based on all the information that is available at a given point in time.

Much of the literature and many of the procedures in PDBA discuss the outcome of building assessment procedures, often expressed as a placard colour or category (e.g., White/Green: Safe for Use; Red: Unsafe, etc.).

However, the researchers in this study found that, in practice, the status of a building is in a constant state of flux, and changes based on multiple factors. For example, using the PDBA outcome categories, buildings may be unassessed, White/Green, Yellow, or Red at different times during an event. The building is "unassessed" and has "no status" until a team has performed a building assessment. The initial assessed status may change for several reasons – a building may be initially cleared by a USAR team, but subsequently categorized as Yellow in Rapid Building Assessment, then changed to White/Green after a Detailed Building Assessment. Alternatively, a building may be declared as White/Green through the building assessment process, but later declared unsafe due to geotechnical assessment or assessment of neighbouring buildings as unsafe and a potential hazard due to imminent collapse.

Study participants described how buildings may undergo multiple assessments due to aftershocks or more detailed assessments as the effects of an event on specific types of buildings become apparent over time.

In addition, the status of a building changes over time as subsequent assessments, including owner-initiated engineering and functional assessments and repairs are initiated or demolition (of parts or the whole structure) is undertaken.

The concept of Building Status also includes other information about a building, such as its geographic location, importance, functions (including whether or not it is part of a community's critical infrastructure), vulnerability to hazards, previous history through building permits and plans, and usefulness for post-disaster functions (e.g., temporary housing). Building status may also include ongoing intelligence based on building surveillance and seismic monitoring programs, or ongoing assessment of a building designated as an indicator building for PDBA operations.

1.9 PLACARDS

Please refer to Section 2, Placarding Systems for further information on existing PDBA Placard use.

1.10 ASSESSMENT PERSONNEL

ROLES, RESPONSIBILITIES, AND ADMINISTRATION STRUCTURES

Please refer to Section 1.2 Administration, above, for examples of personnel charts and descriptions of roles and expectations for assessment personnel.

PDBA TRAINING

Please refer to the following Section 2 for information on PDBA training.

LEGAL AND LIABILITY ISSUES

Legal and liability issues vary significantly between countries, and even between programs within countries. Many systems employ standardized Memoranda of Agreements or similar documents to allow professionals such as engineers and architects to provide services in a post-disaster setting.

The following resources provide information and/or resources regarding legal and liability issues:

- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). *Field guide: Rapid post disaster building usability assessment - Earthquakes.*
    - Sample Memorandum of Understanding (MOU) for Assessors, pp. 92 – 97.
- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). *Field guide: Rapid post disaster building usability assessment - Flooding.*
    - Sample Memorandum of Understanding (MOU) for Assessors, pp. 75 – 80.
- New Zealand Society for Earthquake Engineering (2009). *Building Safety Evaluation during a State of Emergency: Guidelines for Territorial Authorities.*
    - Sample Memorandum of Understanding (MOU) for Assessors, pp. 56 – 60.
- Governor's Office of Emergency Services (2015). *Post-Disaster Safety Assessment Program: Guideline to the activation and utilization of program resources.*
    - Legal Issues, pp. 17 – 19.

1.11 TRAINING

Please refer to Section 2: PDBA Training for further information on PDBA training programs.

02

PDBA TOPICS

INTRODUCTION

This section contains resources and references on specific topics in post disaster building assessment, including:

- PDBA Systems
- PDBA Processes
- Field Guides
- Placard Systems
- Building Taxonomies
- Forms and Resources
- PDBA Training

EXISTING PDBA PROGRAMS

This section provides a brief description of several active, English-language PDBA programs and resources that informed this research study. Please refer to following sections for descriptions of PDBA processes and links to other resources from these programs.

BC HOUSING

BC HOUSING RAPID DAMAGE ASSESSMENT PROGRAM

BC Housing was created in 1967 through an Order-in-Council under the Ministry of Lands, Parks and Housing Act to deliver on the provincial government's commitment to the development, management and administration of housing. Under the Homeowner Protection Act, BC Housing also has responsibilities related to licensing of residential builders, administering owner builder authorizations, overseeing home warranty insurance, and carrying out research and education to improve the quality of residential construction and consumer protection. BC Housing has a Board of Commissioners that is responsible for corporate governance, and an organizational structure with six branches. Additional information such as our mandate, mission, vision, and values can be found on the BC Housing website.

Under of the BC Earthquake Immediate Response Plan (page 42), https://www2.gov.bc.ca/assets/gov/public-safety-and-emergency-services/emergency-preparedness-response-recovery/provincial-emergency-planning/irp.pdf, BC Housing is responsible to:

- Establish and lead the Building Damage Assessment Branch at the PECC/PERRC
- Provide rapid damage assessment teams, prioritize and coordinate rapid damage assessment of provincial and other key facilities
- Provide rapid damage assessment training, assessment coordination, action plans, response/recovery priorities and authority to access and restrict access to government housing property

The following resources are available through BC Housing (https://www.bchousing.org/about/rapid-damage-assessment):

- Rapid Damage Assessment Field Manual
- Placards:
    - Inspected Placard
    - Unsafe Placard
    - Restricted Use Placard
    - Rapid Damage Building Inspection - FAQs regarding Placards
- Rapid Damage Assessment Form
- Job Descriptions:
    - Building Safety Damage Assessment Program Coordinator
    - Safety Assessment Program Evaluator
- Others:
    - Building Damage Assessment – Emergency Operations Centre sample
    - Pre-Deployment Checklist – Damage Assessment and Emergency Lodging
    - Deployment Checklist – Building Damage Assessment
    - Safety Assessment Program – Evaluator Go-Kit
    - Damage Assessment Summary – Sample

NEW ZEALAND MINISTRY OF BUSINESS, INNOVATION AND EMPLOYMENT

New Zealand's Ministry of Business, Innovation and Employment maintains an extensive set of resources to support post disaster building management, including field guides and training. "MBIE developed and updated these field guides, building assessment forms and placards to reflect the recommendations of the Canterbury Earthquake Royal Commission (CERA). They apply nationally and can be used by authorised civil defence emergency management officials and engineers."

The following resources are available through the MBIE site https://www.building.govt.nz/managing-buildings/post-emergency-building-assessment/:

- Managing buildings in an emergency – guidance for decision-makers and territorial authorities
- Building assessment field guides, forms, and resources
- Building assessment training
- Building owner and manager post-emergency guide
- Post-emergency resources

NEW ZEALAND MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT (CDEM)

"The Ministry of Civil Defence & Emergency Management provides leadership in reducing risk, being ready for, responding to and recovering from emergencies. It manages central government's response and recovery functions for national emergencies, and supports the management of local and regional emergencies." In an emergency, CDEM manages "the central government response to, and recovery from, large scale emergencies resulting from geological (earthquakes, volcanic unrest, landslides, tsunami), meteorological (coastal hazards, floods, severe winds, snow) and infrastructure failure. MCDEM is the lead agency for these emergencies."

https://www.civildefence.govt.nz/

The CDEM site provides a number of resources and information on overall emergency management: https://www.civildefence.govt.nz/about/about-the-ministry/

PROTEZIONE CIVILE, PRESIDENZA DEL CONSIGLIO DEI MINISTRI DIPARTMIMENTO DELLA PROTEZIONE CIVILE, ITALY

"The Civil Protection Department has been grounded in the offices of the Presidency of the Council of Ministers since 1982. It has a guiding role, in agreement with regional and local governments, of projects and activities for the prevention, forecast and monitoring of risks and intervention procedures that are common to the whole system. The Department coordinates the response to natural disasters, catastrophes or other events - events of C type - that intensity and extent, should be faced with extraordinary powers and means. Moreover, also in agreement with the regional governments and local authorities, working in the drafting of legislation on the prevention of risks and regulatory measures needed to cope with disasters and minimize damage to people and property. It promotes drills, national and international training projects and activities that contribute to spreading the culture of civil protection."

http://www.protezionecivile.gov.it/jcms/en/dipartimento.wp

MATILDA: MULTINATIONAL MODULE ON DAMAGE ASSESSMENT AND COUNTERMEASURES

"Matilda Project is focused on the design and implementation of a multinational European Civil Protection threefold resource, skilled for post-earthquake building safety assessment and countermeasures, to be deployed in international emergencies.

The resource is based on the experience developed within the DrHouse project, funded by the European Commission under the "Preparatory Action on an EU Rapid Response Capability".

"Build-Safe" is composed by 3 different Resources, respectively dedicated to visual damage and safety assessment (Basic Safety Assessment, BSA), advanced experimentalnumerical assessment (Advanced Safety Assessment, ASA), and to short term countermeasures on damaged buildings (Short Term Countermeasures, STC).

Three different countries participate to Matilda: Italy, Croatia and Slovenia. The Project Coordinator is the Italian Civil Protection Department, which also coordinates BSA resource. Partners to the Project are also Eucentre Foundation, responsible for the ASA resource, Italian Fire Department, Public Aid and Civil Defence, responsible for the STC resource, the Administration of the Republic of Slovenia for Civil Protection and Disaster Relief (ACPDR) and the National Protection and Rescue Directorate (NPRD) – established in Croatia."

https://projmatilda.wordpress.com/

APPLIED TECHNOLOGY COUNCIL (ATC)

"The Applied Technology Council (ATC) is a nonprofit, tax-exempt corporation established in 1973 through the efforts of the Structural Engineers Association of California. ATC's mission is to develop and promote state-of-the-art, user-friendly engineering resources and applications for use in mitigating the effects of natural and other hazards on the built environment. ATC also identifies and encourages needed research and develops consensus opinions on structural engineering issues in a nonproprietary format. ATC thereby fulfills a unique role in funded information transfer."

https://www.atcouncil.org/about-atc

https://www.atcouncil.org/

ATC-20 and ATC-45 provide guidance for building safety evaluation after earthquakes, windstorms and floods. Note that ATC is used by the California Office of Emergency Services (CalOES) Safety Assessment Program (SAP).Resources available through the ATC website include https://www.atcouncil.org/products/training-info1:

- ATC-20, ATC-20 SAP, ATC-45, ATC-20 and ATC-45, and ATC-20 and ATC-45 training
- Placards
- Field Manuals for ATC-20 Postearthquake Safety Evaluation of Buildings and ATC-45 Safety Evaluation of Buildings after Windstorms and Floods

CALIFORNIA OFFICE OF EMERGENCY SERVICES SAFETY ASSESSMENT PROGRAM (SAP)

"The Safety Assessment Program (SAP) utilizes volunteers and mutual aid resources to provide professional engineers and architects and certified building inspectors to assist local governments in safety evaluation of their built environment in the aftermath of a disaster. The program is managed by Cal OES, with cooperation from professional organizations. SAP produces two resources: SAP Evaluators, described above, and SAP Coordinators, which are local government representatives that coordinate the program. Cal OES issues registration ID cards to all SAP Evaluators that have successfully completed the program requirements."

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

Resources available through the California SAP program include:

- ATC-20 Evaluation Forms (for use in SAP Activation)
- ATC-45 Evaluation Forms (for use in SAP Activation)
- Job Aid for SAP Coordinator
- SAP Coordinator Manual
- SAP Evaluator Job Aid
- Evaluator Student Manual
- Frequently Asked Questions
- SAP Guidelines
- SAP Informational Flyer
- SAP Forms for specific situations (e.g., airport, bridge, geotechnical evaluation, etc.)

NATIONAL COUNCIL OF STRUCTURAL ENGINEERS ASSOCIATIONS (NCSEA)

"The National Council of Structural Engineers Associations (NCSEA) was formed to constantly improve the standard level of practice of the structural engineering profession, and to provide an identifiable resource for those needing communication with the profession. The Association's vision is to be recognized as the leading advocate for the practice of structural engineering via its ongoing mission of representing and strengthening its 44 Member Organizations."

http://www.ncsea.com/

"The International Code Council and NCSEA have joined forces to create the Disaster Response Alliance (DRA) to help communities get up and running as quickly as possible after a major disaster. The DRA maintains a single, national database of skilled volunteers willing to assist with response and recovery activities. These activities include post-disaster safety assessments, rapid safety assessments, detailed safety assessments, other building damage assessments, inspections and other code-related functions in the aftermath of a disaster. The DRA's national database of volunteers is available to local and state jurisdictions as well as federal government agencies for pre- and post-disaster assistance. "

http://www.ncsea.com/resources/emergencyresponse/

Resources available include http://www.ncsea.com/resources/emergencyresponse/:

- Structural Engineers Emergency Response plan documents
- Disaster Assessment Professionals – Qualification Matrix
- Structural Engineers Emergency Response Plan Manual

PDBA PROCESSES AND PROCEDURES

Post disaster building assessment processes vary between programs, but the research team found a general flow. Most programs include an initial area assessment (Windshield Assessment), followed by a Rapid Assessment Phase, Detailed Assessment, and a comprehensive Engineering or Functional Assessment. The goals, phases, and procedures in specific programs differed, primarily based on the overall goals of PDBA.

Descriptions and information on PDBA processes and procedures can be found in the following resources:

- BC PDBA Project
  - Generic Building Assessment Procedures

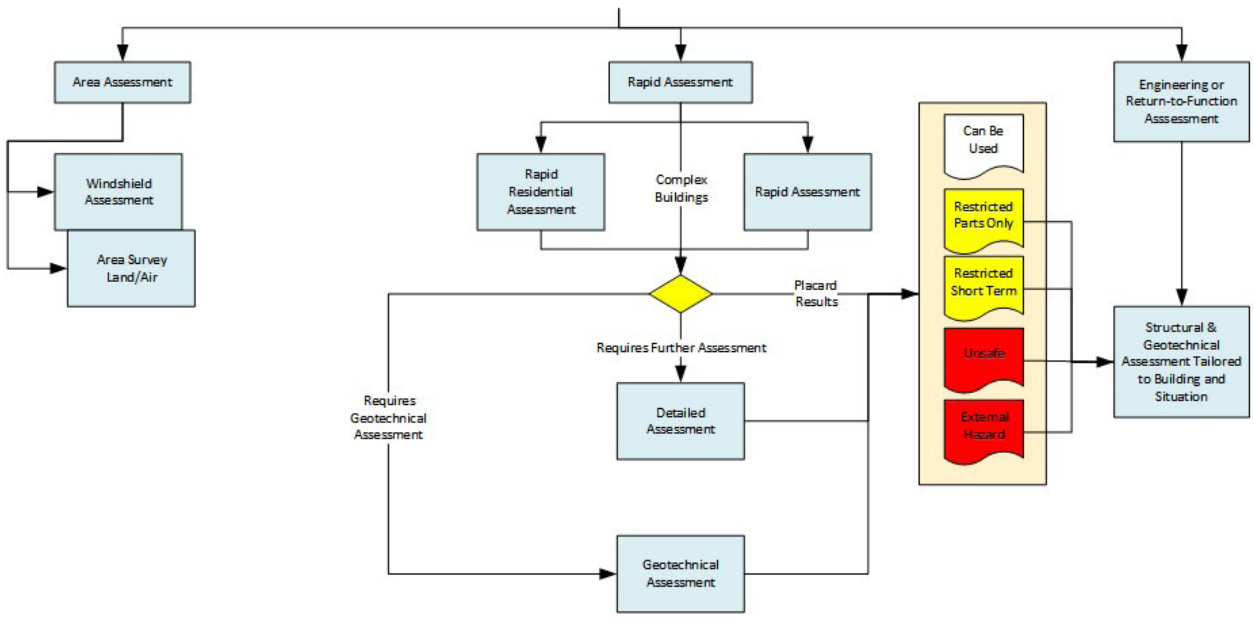


Figure 12. Generic PDBA Building Assessment Procedures.

- BC Housing. (2017). Field manual: Rapid Damage Assessment
  - Rapid Damage Assessment Procedures, pp. 7 – 8.

- Applied Technology Council. (1989). ATC 20: Procedures for postearthquake safety evaluation of buildings.
  - Chapter 3. General Procedures for Building Safety Evaluation, pp. 13 – 18.
  - Chapter 4. Rapid Evaluation Method, pp. 19 – 24.
  - Chapter 5. Detailed Evaluation Method, pp. 25 – 33.
  - Chapter 14. Engineering Evaluation Method, pp. 111 – 112.

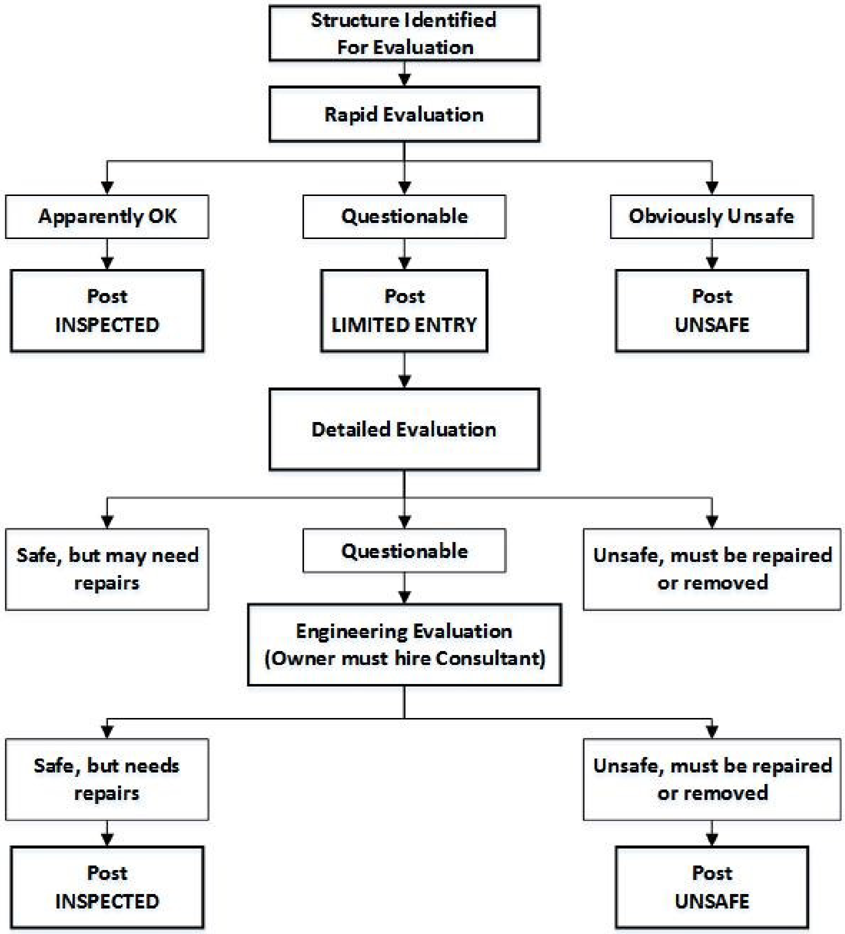


Figure 13. Adapted from ATC-20, Figure 3.1 Flowchart showing normal building safety evaluation and posting process, p. 14.

- New Zealand Ministry of Business, Innovation and Employment. (2014). Field guide: Rapid post disaster building usability assessment - Earthquakes.
    - 5. Building Assessment Overview, pp. 15- 39.
    - 6. Residential Rapid Assessment – Simple Assessment, pp. 40 – 47.
    - 7. Level 1 Rapid Assessment – Complex Residential and All Non-Residential Buildings, pp. 48 – 53.
    - 8. Level 2 Rapid Assessment – Complex Residential and All Non-Residential Buildings, pp. 54 – 59.

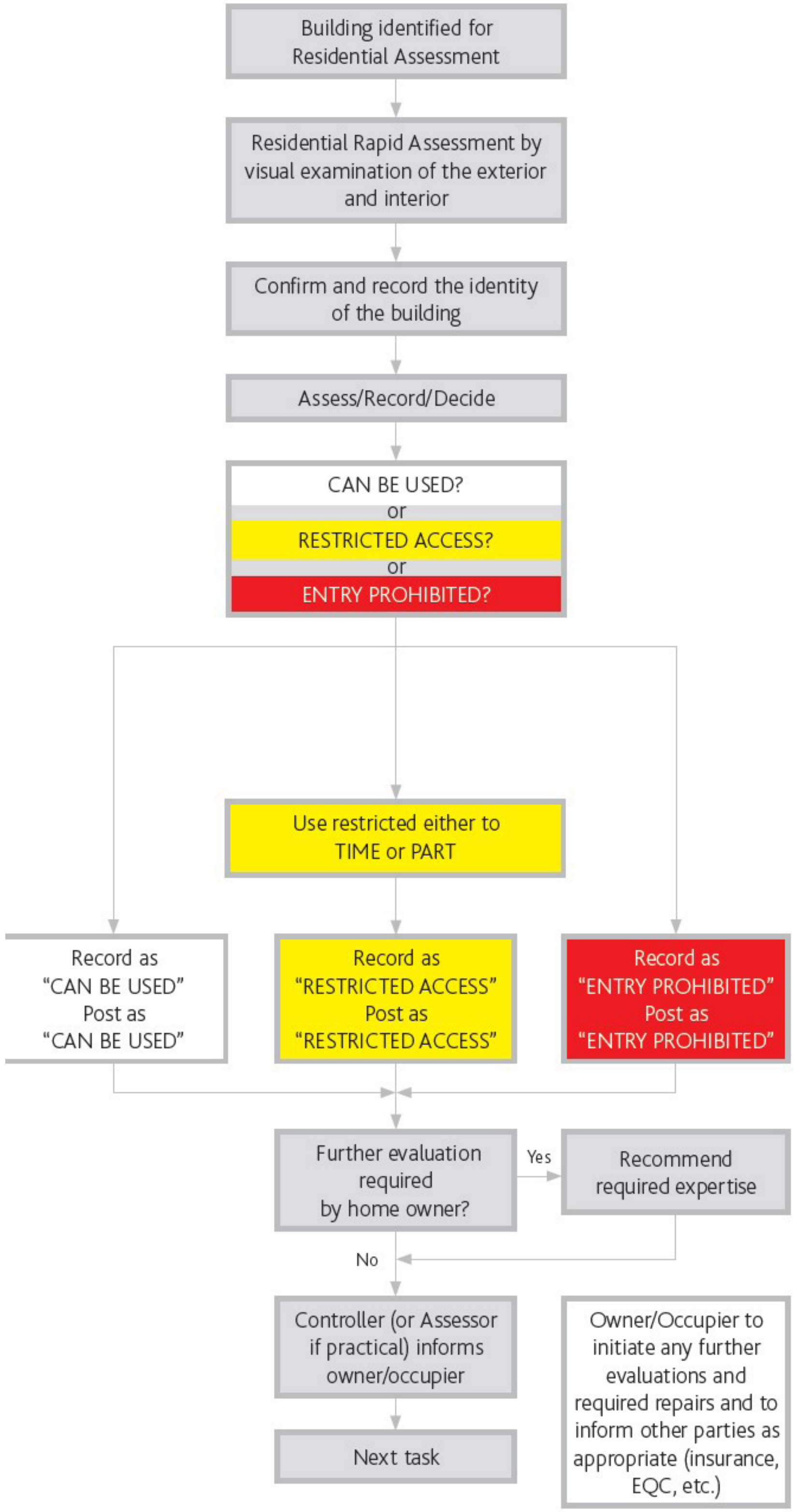


Figure 14. Residential Rapid Assessment – Simple Residential Buildings.

Source: New Zealand Ministry of Business, Innovation and Employment. (2014). *Field guide: Rapid post disaster building usability assessment - Earthquakes,* pp. 40 – 41.

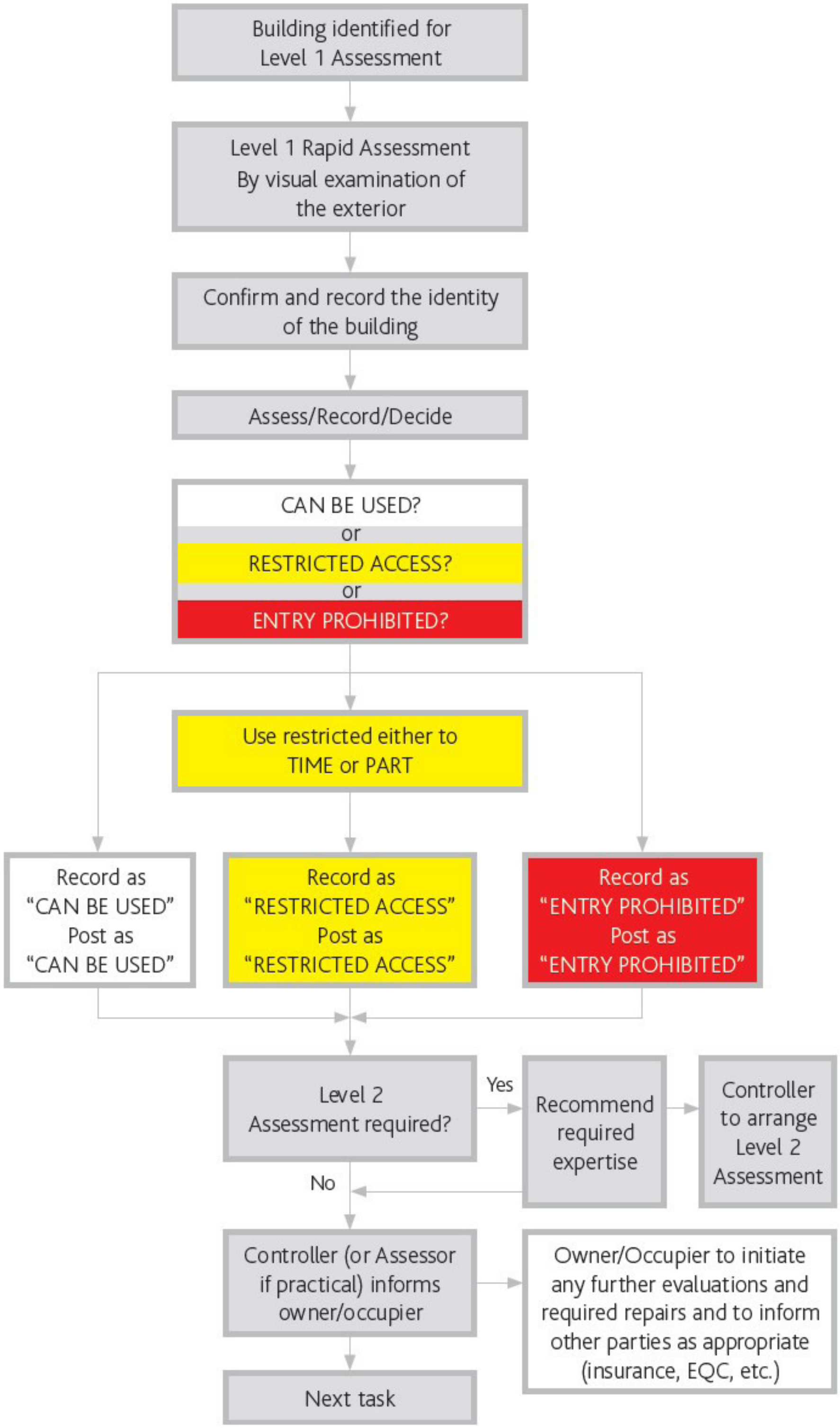


Figure 15. Level 1 Rapid Assessment – Complex Residential and All Non-Residential Buildings.

Source: New Zealand Ministry of Business, Innovation and Employment. (2014). *Field guide: Rapid post disaster building usability assessment - Earthquakes*, pp. 48 – 49.

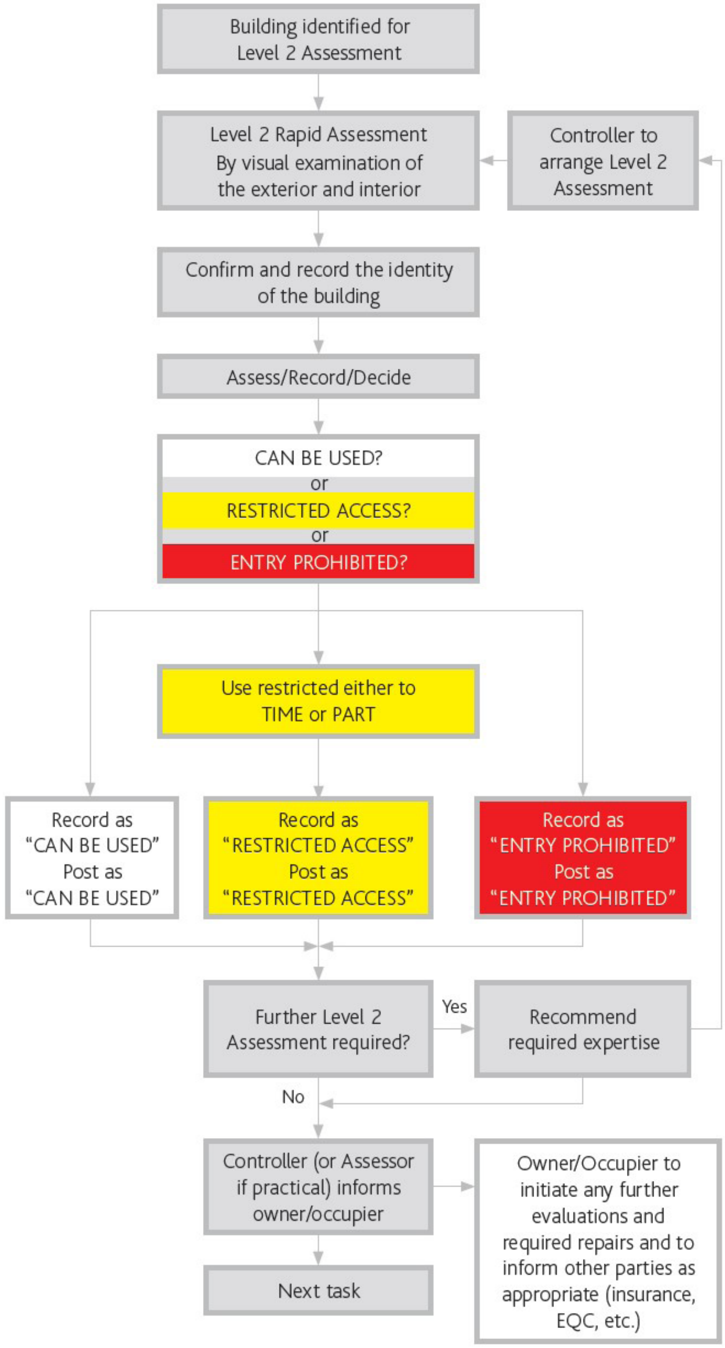


Figure 16. Level 2 Rapid Assessment – Complex Residential and All Non-Residential Buildings.

Source: New Zealand Ministry of Business, Innovation and Employment. (2014). *Field guide: Rapid post disaster building usability assessment - Earthquakes*, pp. 54 – 55.

- New Zealand Ministry of Business, Innovation and Employment. (2014). *Field guide: Rapid post disaster building usability assessment - Flooding.*
    - 5. Building Assessment Overview, pp. 13- 37.
    - 6. Residential Rapid Assessment – Simple Assessment, pp. 38 – 45.
    - 7. Rapid Assessment – Complex Residential and All Non-Residential Buildings, pp. 46 – 53.
    - 8. Level 2 Rapid Assessment – Complex Residential and All Non-Residential Buildings, pp. 54 – 59.

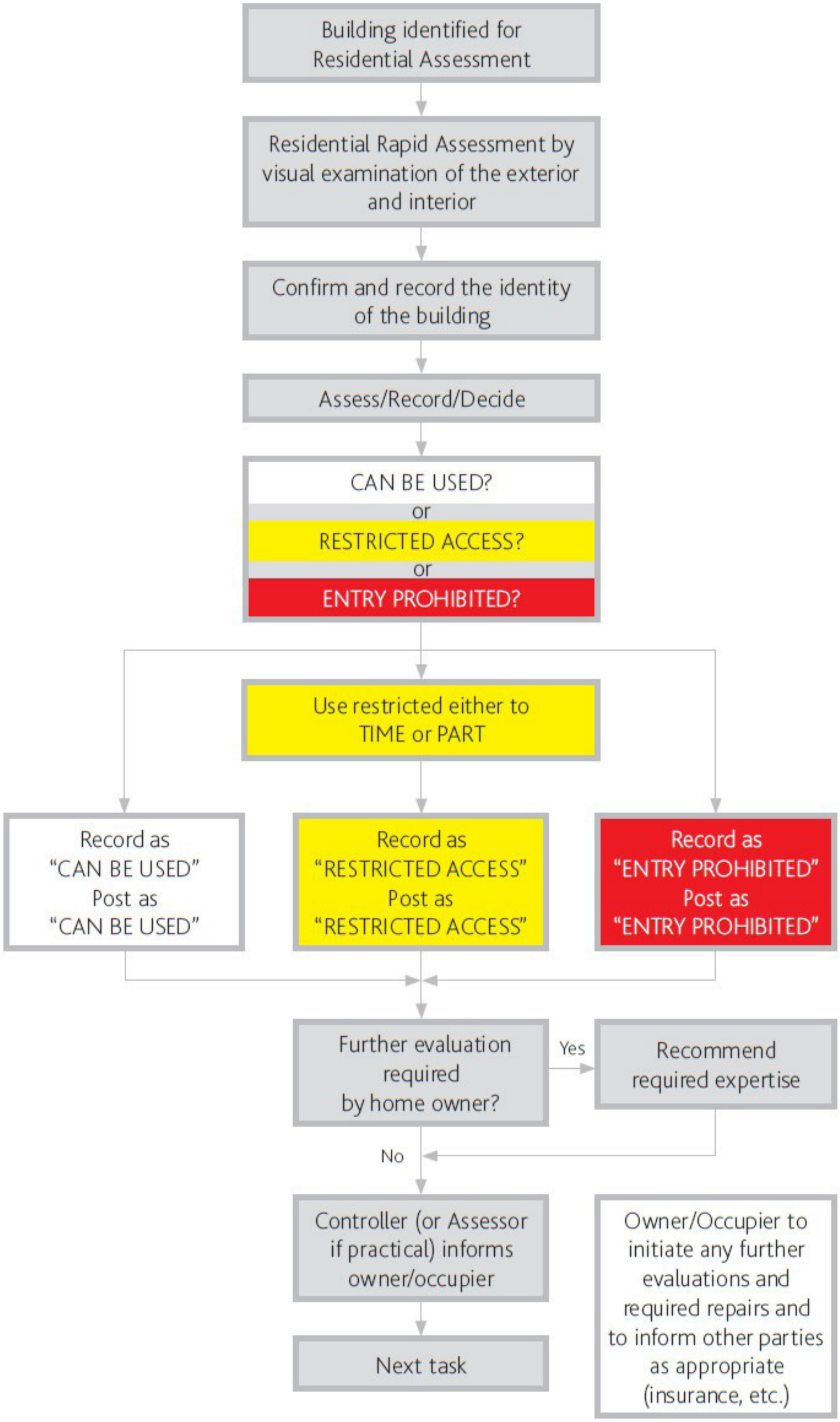


Figure 17. Flooding: Residential Rapid Assessment – Simple Residential Buildings.

Source: New Zealand Ministry of Business, Innovation and Employment. (2014). *Field guide: Rapid post disaster building usability assessment - Flooding,* pp. 38 – 39.

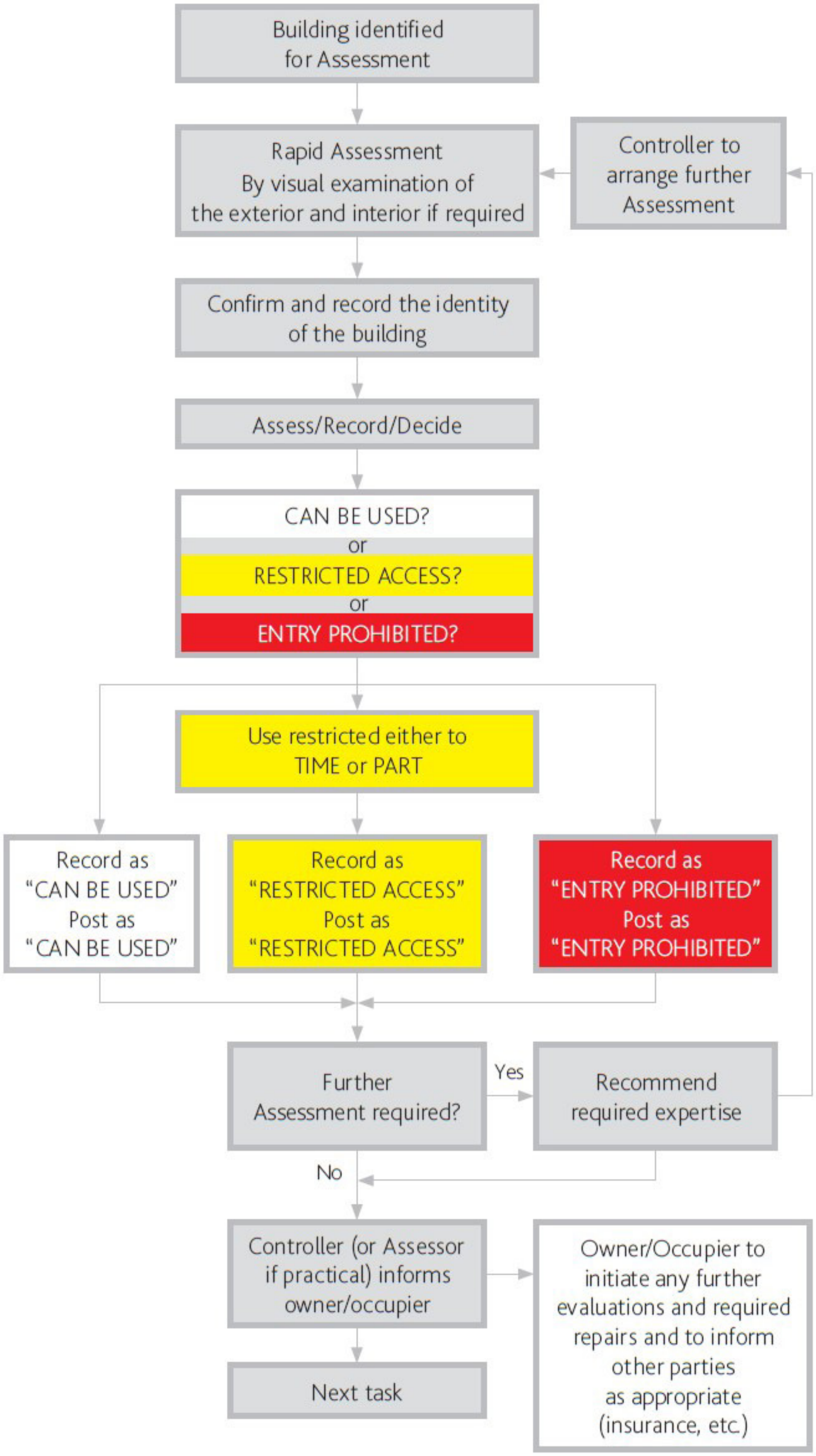


Figure 18. Flooding: Rapid Assessment – Complex Residential and all Non-Residential Buildings.

Source: New Zealand Ministry of Business, Innovation and Employment. (2014). *Field guide: Rapid post disaster building usability assessment - Flooding*, pp. 46 – 47.

- New Zealand Ministry of Business, Innovation and Employment. (2017). *Field guide: Rapid post disaster building usability assessment - Geotechnical.*
    - Rapid Geotechnical Assessment Process, pp. 13 – 26.

- Anagnostopoulos, S., Moretti, M., Panoutsopoulou, M., Panagiotopoulou, D., & Thoma, T. (2004). Post-earthquake damage and usability assessment of buildings: further development and applications. Final report. Patras, Greece: European Commission-DG Environment, and Civil Protection EPPO.
  - 2.3 How the operation is carried out, pp. 9 – 14.
  - 2.4 Procedure of the Damage Assessments, pp. 14 – 23.

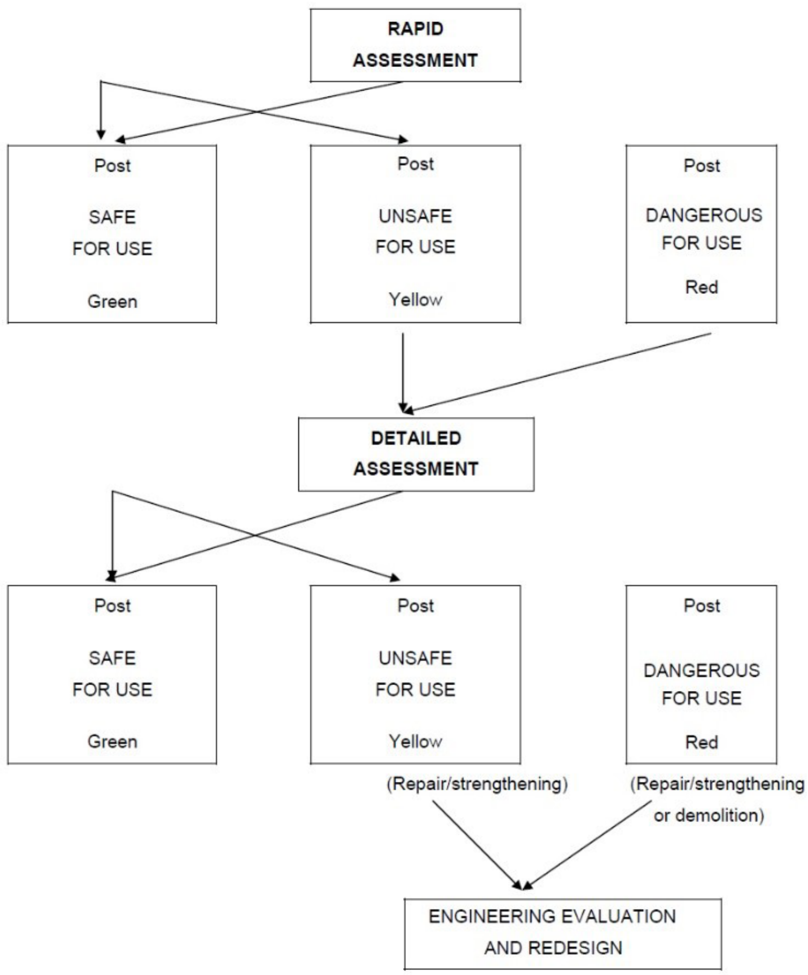


Figure 19. Procedure for emergency assessment of buildings safety after a damaging earthquake.

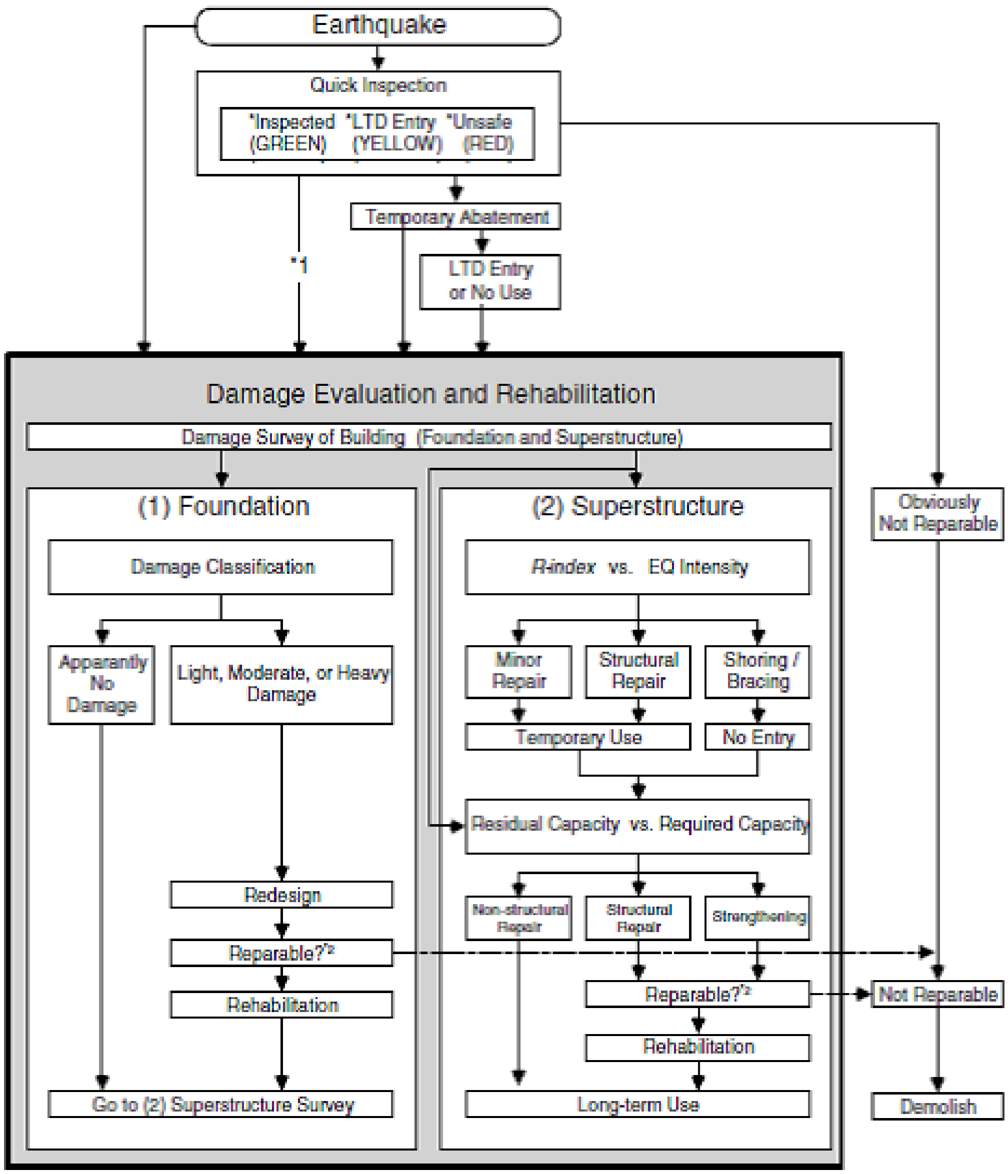
Source: Anagnostopoulos, S., Moretti, M., Panoutsopoulou, M., Panagiotopoulou, D., & Thoma, T. (2004). *Post-earthquake damage and usability assessment of buildings: further development and applications. Final report,* p. 13.

- Saito, T., & Thakur, S. K. (2012). Post-Earthquake Quick Risk Inspection System for Buildings.
  - 2. Quick Risk Inspection System (Japan), pp. 5 – 7.

- Kaminosono, T., Kumazawa, F., & Nakano, Y. (2002). National Institute of Land and Infrastructure Management; Ministry of Land, Infrastructure, and Transport.
  - NOTE: Report on efforts of Japanese Disaster Relief team to the Kocaeli, Turkey in August, 1999.
  - 3.2 Quick Inspection Procedure, p. 12 – 14.

Figure 20. Source: Kaminosono, T., Kumazawa, F., & Nakano, Y. (2002). *National Institute of Land and Infrastructure Management; Ministry of Land, Infrastructure, and Transport*, p. 7.

- Nakano, Y., Maeda, M., Kuramoto, H., & Murakami, M. (2004, August). Guideline for post-earthquake damage evaluation and rehabilitation of RC buildings in Japan
    - Damage Evaluation and Rehabilitation, pp. 2 – 3.



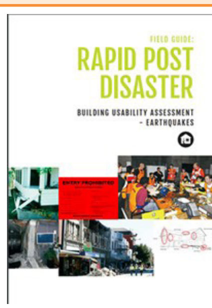
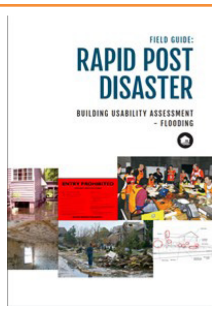
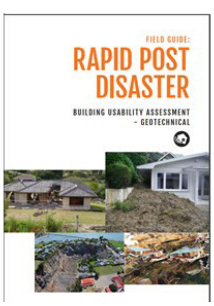
*1 Damage evaluation fundamentally includes buildings after quick inspection since the inspection results do not necessarily provide sufficient information related to the residual seismic capacity which is most essential to judge appropriateness of continued long-term use of buildings.
*2 Economic as well as technical issues should be considered.

Figure 1: General Flow of Damage Evaluation and Rehabilitation Assumed in the Guideline

Figure 21. Source: Nakano, Y., Maeda, M., Kuramoto, H., & Murakami, M. (2004, August). *Guideline for post-earthquake damage evaluation and rehabilitation of RC buildings in Japan*, p. 3.

FIELD GUIDES

Field guides are available from a number of PDBA programs. The following are resources that were referenced in this study. Note that some of these resources may be older editions, or from programs that are no longer operating. Please check with the source organization for the most current versions and for information on accessing these documents.

BC HOUSING	
	*BCH Field Manual: Rapid Damage Assessment* https://www.crownpub.bc.ca/Product/Details/7680003575_S
	BCH-Handout Package - Coordination of DA 20160722
NEW ZEALAND MINISTRY OF BUSINESS, INNOVATION, AND EMPLOYMENT	
	*Field guide: Rapid post disaster building usability assessment – Earthquakes* https://www.building.govt.nz/managing-buildings/post-emergency-building-assessment/field-guides-and-tools-for-building-assessment/rapid-post-disaster-building-assessmentearthquake/
	*Field guide: Rapid post disaster building usability assessment - Flooding.* https://www.building.govt.nz/managing-buildings/post-emergency-building-assessment/field-guides-and-tools-for-building-assessment/rapid-post-disaster-building-assessment-flooding/
	*Field guide: Rapid post disaster building usability assessment: Geotechnical* https://www.building.govt.nz/assets/Uploads/managing-buildings/post-emergency-building-assessment/building-usability-assessment-geotechnical.pdf

APPLIED TECHNOLOGY COUNCIL

ATC 20-1: Field Manual: Postearthquake safety evaluation of buildings

Available for purchase at: https://store.atcouncil.org/

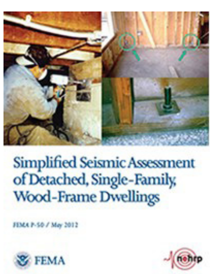
ATC 20: Procedures for postearthquake safety evaluation of buildings.

ATC 20-2: Addendum to the ATC-20 postearthquake safety evaluation procedures.

Available for purchase at: https://store.atcouncil.org/

ATC-45: Field manual: Safety evaluation of buildings after windstorms and floods

Available for purchase at: https://store.atcouncil.org/



FEMA P-50: Simplified seismic assessment of detached, single-family wood-frame dwellings (prepared by ATC).

https://www.atcouncil.org/images/files/FEMA_P-50.pdf

EUROPEAN COMMISSION JOINT RESEARCH CENTRE, INSTITUTE FOR THE PROTECTION AND SECURITY OF THE CITIZEN

Field Manual for past-earthquake damage and safety assessment and short term countermeasures (AeDES).

https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/field-manual-post-earthquake-damage-and-safety-assessment-and-short-term-countermeasures

PLACARD SYSTEMS

Placard systems are used to document and display the results of post disaster building assessments. There is a general use of three categories of outcome: inspected/safe, restricted use, and unsafe. However, within these categories, there can be considerable differences in the terminology, definitions, criteria for each category, and restrictions imposed by each category. The following resources were useful in identifying the range and content of placards, placard systems, and placard procedures. Several of the resources in this section have been updated or supplemented since the original study. Please refer to the referenced organizations and programs for the most current material.

PLACARD CATEGORIES

The following resources discuss placard categories and descriptions:

- BC Housing (2017). Field manual: Rapid Damage Assessment (Edition 4.3), pp. 17 – 19.
- Applied Technology Council (1989). ATC 20: Procedures for postearthquake safety evaluation of buildings, pp. 7 – 13.
- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). Field guide: Rapid post disaster building usability assessment - Earthquakes, pp. 26 – 31.
- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). Field guide: Rapid post disaster building usability assessment - Flooding, pp. 23 – 29.
- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2017). Field guide: Rapid post disaster building usability assessment - Geotechnical, pp. 20 – 25.
- Saito, T., & Thakur, S. K. Post-Earthquake Quick Risk Inspection System for Buildings, p. 6.

PLACARD DOCUMENTATION

The following resources discuss procedures for completing placards and forms:

- BC Housing (2017). Field manual: Rapid Damage Assessment (Edition 4.3), p. 20.
- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). Field guide: Rapid post disaster building usability assessment - Earthquakes, pp. 60 – 62.

POSTING, CHANGING, AND REMOVING PLACARDS

The following resources discuss procedures for posting, changing, and removing placards:

- BC Housing (2017). Field manual: Rapid Damage Assessment (Edition 4.3), p. 20.
- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). Field guide: Rapid post disaster building usability assessment - Earthquakes, pp. 32 – 35.
- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). Field guide: Rapid post disaster building usability assessment - Flooding. Wellington, NZ: MBIE, pp. 30 – 33.
- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2017). Field guide: Rapid post disaster building usability assessment - Geotechnical, pp. 25 – 26.

PLACARD EXAMPLES AND CATEGORIES

The following table provides several examples of placard systems referenced in this study.

<table>
<tr><th colspan="4">BC HOUSING</th></tr>
<tr><th>OBSERVED DAMAGE</th><th>ASSESSMENT OUTCOME</th><th>PLACARD ISSUED</th><th>PLACARD IMAGE</th></tr>
<tr><td>Light or no damage (low risk)</td><td>G = INSPECTED NO RESTRICTION OF USE OR OCCUPANCY

Structure has no apparent structure or safety hazard was observed</td><td>INSPECTED

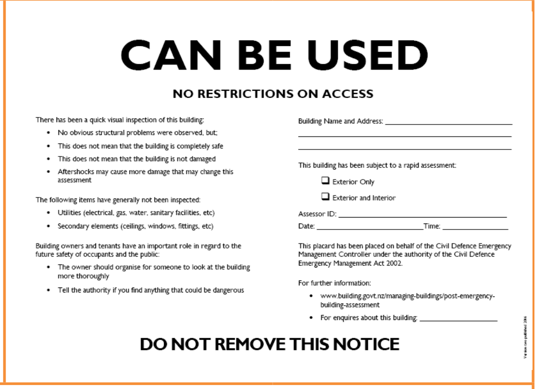
(GREEN)</td><td>INSPECTED
NO RESTRICTION OF USE OR OCCUPANCY
Facility name and address: ____ Date ____ Time ____
This structure has been inspected for life safety purposes only and no apparent structural or safety hazard was observed that would restrict use or occupancy.
☐ Inspected Exterior Only ☐ Inspected Exterior and Interior
Inspector Comments: ____
A more comprehensive inspection may reveal safety hazards.
Report any unsafe condition to local authorities; re-inspection may be required.
This facility was inspected under emergency conditions for: ____ (Jurisdiction)
The property / building was not inspected / assessed for legislative or code compliance or insurance or financial reimbursement purposes.
The assessment did not include inspection of concealed / hidden areas, equipment operation, presence of insects, rot and hazardous materials such as; asbestos, radon gas, lead paint, urea formaldehyde, toxic chemicals, mould, and/or contamination.
Inspector ID / Agency ____</td></tr>
<tr><td>Available at:</td><td colspan="3">https://www.bchousing.org/publications/Inspected-Placard.pdf</td></tr>
<tr><td>Moderate damage (medium risk)</td><td>Y = RESTRICTED USE

Structure has been found to be damaged as described</td><td>RESTRICTED USE

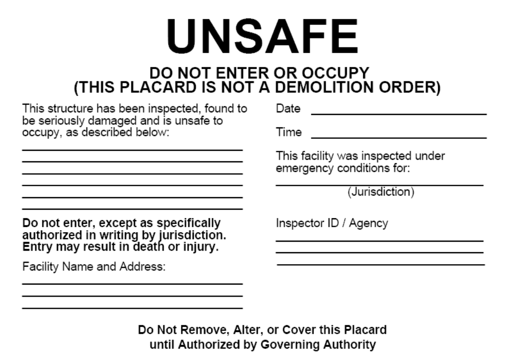
(YELLOW)</td><td>RESTRICTED USE
Facility name and address: ____ Date ____ Time ____
Caution: This structure has been inspected for life safety purposes only and found to be damaged as described below: ____
Entry, occupancy, and lawful use are restricted as indicated below:
☐ Do not enter or use the following areas: ____
☐ Brief entry allowed for access to contents: ____
☐ Do not use flooded/damaged appliances, devices or services (electrical, gas) until recertified by a licensed contractor
☐ Other restrictions: ____
This facility was inspected under emergency conditions for: ____ (Jurisdiction)
The property / building was not inspected / assessed for legislative or code compliance or insurance or financial reimbursement purposes.
The assessment did not include inspection of concealed / hidden areas, equipment operation, presence of insects, rot and hazardous materials such as; asbestos, radon gas, lead paint, urea formaldehyde, toxic chemicals, mould, and/or contamination.
Inspector ID / Agency ____
Do Not Remove, Alter, or Cover this Placard
until Authorised by Governing Authority or licensed contractor</td></tr>
<tr><td>Available at:</td><td colspan="3">https://www.bchousing.org/publications/Restricted-Use-Placard.pdf</td></tr>
<tr><td>Heavy Damage (high risk)</td><td>R = UNSAFE – DO NOT ENTER OR OCCUPY (THIS IS NOT A DEMOLITION ORDER)

Structure has been found to be seriously damaged and unsafe</td><td>UNSAFE

(RED)</td><td>UNSAFE
DO NOT ENTER OR OCCUPY
(THIS PLACARD IS NOT A DEMOLITION ORDER)
Facility name and address: ____ Date ____ Time ____
This structure has been inspected for life safety purposes only and found to be seriously damaged and is unsafe to occupy as described below: ____
Do not enter, except as specifically authorised in writing by the authority having jurisdiction.
Entry may result in death or injury.
This facility was inspected under emergency conditions for: ____ (Jurisdiction)
The property / building was not inspected / assessed for legislative or code compliance or insurance or financial reimbursement purposes.
The assessment did not include inspection of concealed / hidden areas, equipment operation, presence of insects, rot and hazardous materials such as; asbestos, radon gas, lead paint, urea formaldehyde, toxic chemicals, mould, and/or contamination.
Inspector ID / Agency ____
Do Not Remove, Alter, or Cover this Placard
until Authorised by Governing Authority</td></tr>
<tr><td>Available at:</td><td colspan="3">https://www.bchousing.org/publications/Unsafe-Placard.pdf</td></tr>
</table>

NEW ZEALAND			
OBSERVED DAMAGE	ASSESSMENT OUTCOME	PLACARD ISSUED	PLACARD IMAGE
Light or no damage (low risk)	W = CAN BE USED No immediate further evaluation required	CAN BE USED (WHITE)	
Available at:	https://www.building.govt.nz/assets/Uploads/managing-buildings/post-emergency-building-assessment/placards-white.pdf		
Moderate damage (medium risk)	Y1 = USE RESTRICTED IN PART(S) No entry to parts until risk reduced by repair or demolition Y2 = USE RESTRICTED to SHORT TERM ENTRY: With or without supervision	RESTRICTED USE (YELLOW)	
Available at:	https://www.building.govt.nz/assets/Uploads/managing-buildings/post-emergency-building-assessment/placards-yellow.pdf		
Heavy Damage (high risk)	R1 = ENTRY PROHIBITED At risk from external factors such as adjacent buildings or from ground failure R2 = ENTRY PROHIBITED Significant damage	ENTRY PROHIBITED (RED)	
Available at:	https://www.building.govt.nz/assets/Uploads/managing-buildings/post-emergency-building-assessment/placards-red.pdf		
Diagram of Restricted Areas	Optional Diagram sheet for Placards		

ATC-20 AND ATC-45			
OBSERVED DAMAGE	ASSESSMENT OUTCOME	PLACARD ISSUED	PLACARD IMAGE
Available at:	https://www.atcouncil.org/products/downloadable-products/placards		
Light or no damage (low risk)	G = INSPECTED LAWFUL OCCUPANCE PERMITTED Structure has no apparent structural hazard found	INSPECTED (GREEN)	 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
Available at:	ATC-20: https://www.atcouncil.org/pdfs/iplacard.pdf		
	ATC-45: https://www.atcouncil.org/pdfs/ATC45Inspected.pdf		
Moderate damage (medium risk)	Y1 = RESTRICTED USE WITH INSTRUCTIONS Structure found to be damaged	RESTRICTED USE (YELLOW)	 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: ☐ Do not enter the following areas: ☐ Brief entry allowed for access to contents: ☐ Other restrictions: 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
	Y1 = RESTRICTED USE Structure found to be damaged	RESTRICTED USE (YELLOW)	 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: ☐ Do not enter the following areas: ☐ Brief entry allowed for access to contents: ☐ Other restrictions: 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
Available at:	ATC-20: https://www.atcouncil.org/pdfs/rplacard.pdf		
	ATC-20: https://www.atcouncil.org/pdfs/mplacard.pdf		
	ATC-45: https://www.atcouncil.org/pdfs/ATC45Restricted.pdf		
	ATC-45: https://www.atcouncil.org/pdfs/ATC45Restrictedboxes.pdf		

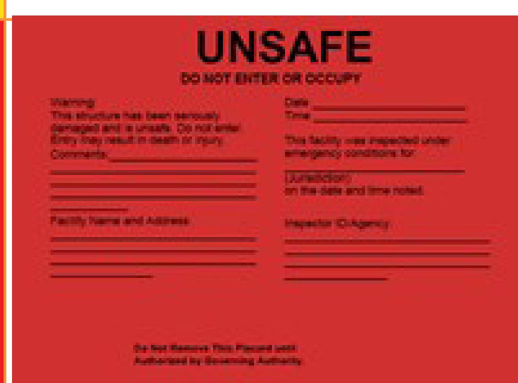
Heavy Damage (high risk)	RED UNSAFE Do not enter or occupy Structure found to be seriously damaged and is unsafe to occupy	UNSAFE (RED)	 UNSAFE DO NOT ENTER OR OCCUPY (THIS PLACARD IS NOT A DEMOLITION ORDER) This structure has been inspected, found to be seriously damaged and is unsafe to occupy, as described below: Date Time This facility was inspected under emergency conditions for: (Jurisdiction) **Do not enter, except as specifically authorized in writing by jurisdiction. Entry may result in death or injury.** Inspector ID / Agency Facility Name and Address: **Do Not Remove, Alter, or Cover this Placard until Authorized by Governing Authority**
Available at:	ATC-20: https://www.atcouncil.org/pdfs/uplacard.pdf		
	ATC-45: https://www.atcouncil.org/pdfs/ATC45Unsafe.pdf		

EUROPE

Source	Goretti, A. (2017). Preparedness and lessons learnt on international interventions on post-earthquake building safety assessment.					
	Note: The following is adapted from a presentation by Dr. A. Goretti at the PDBA Expert Working Group Workshop in June, 2017. The following table compares the outcome categories of several European damage assessment systems.					
	Italy	Cyprus	Greece	Slovenia	Spain	Turkey
GREEN	Usable	Usable	Usable	Usable	Usable	Usable
YELLOW	Partially usable; Usable after counter-measures	Temporarily unusable	Temporarily unusable	Restricted Use	Partially usable; Usable after counter-measures	
RED	Unusable; Unusable only for the external risk	Unusable	Dangerous	Unusable	Unusable; Unusable only for the external risk	Unusable

GREECE (1998)

OBSERVED DAMAGE	ASSESSMENT OUTCOME	PLACARD ISSUED	PLACARD IMAGE
I (GREEN)	Buildings with no visible damages and/or whose original seismic capacity has not been significantly decreased.	Usable	N/A
II (YELLOW)	Buildings whose seismic capacity has been de-creased and/or they pose a danger condition due to damage of non structural elements.	Temporarily Unusable	N/A
III (RED)	Buildings with heavy dam-age. Imminent danger of sudden collapse. Entry is absolutely prohibited.	Dangerous	N/A

NEPAL (DRAFT 2009)			
SOURCE	Goretti, A. (2017). *Preparedness and lessons learnt on international interventions on post-earthquake building safety assessment.* Guragain, R., Shrestha, H., & Kandel, R. C. (2009). *Seismic vulnerability evaluation guideline for private and public buildings. Part II: Post disaster damage assessment.*		
OBSERVED DAMAGE	ASSESSMENT OUTCOME	PLACARD ISSUED	PLACARD IMAGE
No apparent hazard found, although repairs may be required. Original lateral load capacity not significantly decreased. No restriction on use or occupancy.	INSPECTED	USABLE (GREEN)	
Dangerous condition believed to be present. Entry by owner permitted only for emergency purposes and only at own risk. No usage on continuous basis. Entry by public not permitted. Possible major aftershock hazard.	LIMITED ENTRY	Partially Usable Usable after Countermeasures (YELLOW)	
Extreme hazard, may collapse. Imminent danger of collapse from an aftershock. Unsafe for occupancy or entry, except by authorities.	RED UNSAFE	Unusable Unusable only for the exterior risk (RED)	

BUILDING TAXONOMIES

Building assessment is a complex process. One of the factors complicating development of "generic" or generalized procedures is the differences in size, construction, and complexity of buildings. Some PDBA programs have general procedures, then identify factors to consider for different types of building (see, for example, ATC-20). Others outline different assessment processes for different categories of buildings (see the New Zealand procedures for rapid assessment of simple residential buildings). The ***BC PDBA Framework and Recommendations*** suggest that communities should specify the background and experience of assessors based, in part, on the type of building to be inspected.

The following are different ways that various PDBA programs and researchers have classified buildings.

BUILDING TAXONOMIES OR CATEGORIES FOUND IN PDBA PROGRAMS

- BC Housing (2017). *Field manual: Rapid Damage Assessment.*
- The BC Housing field manual identifies three categories:
  - Wood frame
  - Concrete
  - Masonry

  pp. 27 – 36.
- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). *Field guide: Rapid post disaster building usability assessment - Earthquakes*.

  The New Zealand Earthquake assessment identifies several categories of buildings as a basis for choosing a rapid assessment type (see pp. 23 – 25):
  - Simple residential buildings may undergo a rapid residential assessment, involving an external inspection and, if required an internal inspection.
  - Level 1 assessments, involving an external inspection are conducted for residential buildings using typical residential construction types.
  - Level 2 assessments, involving both internal and external inspections are required for:
  - All buildings of 2 or more stories and containing 3 or more household units
  - Essential facilities (hospitals, schools, police and fire stations)
  - Buildings with typical commercial construction details (unreinforced masonry walls, tilt-up panels, multi-story buildings, and others)

  The field guide restates these points as Table 2: Rapid Building Usability Assessment Types, p. 25.

BUILDING TYPE	BUILDING TYPE DESCRIPTION	RAPID ASSESSMENT TYPE
Simple residential buildings	Simple design and only residential use	Residential Rapid Assessment
Complex residential and non-residential buildings	Complex design or non-residential use	Level 1 Rapid Assessment or
Essential facilities and large multi-story buildings	• Hospital • Health care facilities • Police and fire stations • Jails and detention centres • Communication centres • Emergency operation centres • Buildings designated for welfare centres • Buildings or 2 or more stories and containing 3 or more household units	Level 2 Rapid Assessment

Adapted from Table 2: Rapid Building Usability Assessment Types

- ❍ In addition, the manual provides detail information on specific buildings types (pp. 63 - 74):
    - ■ Timber frame structures
    - ■ Reinforced concrete or masonry wall construction
    - ■ Precast concrete tilt-up structures
    - ■ Suspended concrete floors
    - ■ Steel frame structures
    - ■ Unreinforced masonry (URM) structures

- New Zealand Ministry of Business, Innovation and Employment (MBIE) (2014). *Field guide: Rapid post disaster building usability assessment - Flooding.*

The New Zealand Flooding assessment employs a simplified version of the taxonomy presented in the Earthquake guide:

BUILDING TYPE	BUILDING TYPE DESCRIPTION	RAPID ASSESSMENT TYPE
Simple residential buildings	Simple design and only residential use	Residential Rapid Assessment
Essential facilities and large multi-story buildings	Complex design or non-residential use including: • Hospital • Health care facilities • Police and fire stations • Jails and detention centres • Communication centres • Emergency operation centres • Buildings designated for welfare centres	Non-residential and complex residential Rapid Assessment

Adapted from Table 2: Rapid Building Usability Assessment Types

In addition, the Flooding guide provides advice on assessing several specific types of buildings (pp, 57 - 59):

- ❍ Residential buildings
- ❍ Commercial buildings

- Applied Technology Council (1989). *ATC 20: Procedures for postearthquake safety evaluation of buildings.* Redwood City CA: ATC.

  ATC-20 includes technological considerations for safety evaluation for the following types of buildings (pp. 29 – 38):

  - Wood frame construction
  - Unreinforced masonry construction
  - Reinforced masonry construction
  - Steel construction
  - Concrete construction

- The *SAP ATC-20 Rapid Evaluation Safety Assessment form and the Detailed Evaluation Safety Assessment form* lists the following types of construction:

  - Wood frame
  - Steel frame
  - Tilt-up construction
  - Concrete frame
  - Concrete shear wall
  - Unreinforced masonry
  - Reinforced masonry

- Baggio, C., Bernardinin, A., Colozza, R., Corazza, L., Della Bella, M., Di Pasquale, G., Colce, M., Goretti, A., Martinelli, A., Orsini, G., Pap, F., & Zuccaro, G. (2007). *Field Manual for past-earthquake damage and safety assessment and short term countermeasures (AeDES).*

  - The 2007 AeDES manual identifies multiple characteristics of buildings which are used as vulnerability indicators for seismic response (pp, 15 – 37). Inspectors are advised to consider factors such as age of the building, construction, materials, structural typologies, modifications and/or enlargements occurred during the years, instabilities of the foundation soil, etc. The manual identifies several construction types, including wood frame (which are not common in Italy), two categories of masonry buildings (irregular layout or bad quality and regular layout and good quality), reinforced concrete frame structures, reinforced concrete shear wall structures and steel fame structures.

- Dandoulaki, M., Panoutsopoulou, M., & Ioannides, K. (1998, September). An overview of post-earthquake building inspection practices in Greece and the introduction of a rapid building usability evaluation procedure after the 1996 Konitsa earthquake. In Proceedings of 11th European Conference on Earthquake Engineering.

  The inspection form for first degree rapid building usability evaluation in Greece listed the following categories:

  - Reinforced concrete
  - Masonry bearing walls and floors made of reinforced concrete or steel or wood
  - Mixed system (both R.C. and masonry vertical members)
  - Other

- Saito, T., & Thakur, S. K. Post-Earthquake Quick Risk Inspection System for Buildings (n. d.).

  - Saito and Thakur describe separate procedures in Japan for assessing reinforced concrete, steel reinforced concrete, steel, and wooden structures.

CLASSIFICATIONS BASED ON SEISMIC VULNERABILITY

- Ventura, C. E., Finn, W. L., Onur, T., Blanquera, A., & Rezai, M. (2005). Regional seismic risk in British Columbia—classification of buildings and development of damage probability functions. Canadian Journal of Civil Engineering, 32(2), 372-387.
    - "Regional seismic risk estimations are needed in southwestern British Columbia, since it is one of the most seismically active and highly populated regions in Canada. Regional estimations typically involve a large number of buildings, which makes it necessary to establish a building classification system, where the average response to earthquake shaking is assumed to be similar within each building class. In this study, buildings in British Columbia were divided into 31 classes based on their material, lateral load bearing system, height, use, and age. A damage probability matrix (DPM) was then developed for each building class which describes the probability of being in a certain damage level (i.e., light, moderate, heavy, etc.) given the ground shaking intensity." p. 372.

CATEGORY/CLASS	DESCRIPTION
WOOD	
1	Wood light frame residential
2	Wood lifht frame low rise commercial – institutional
3	Wood light frame low rise residential
4	Wood post and bean
STEEL	
5	Light metal frame
6	Steel moment frame low rise
7	Steel moment frame medium rise
8	Steel moment frame high rise
9	Steel braced frame low rise
10	Steel braced frame medium rise
11	Steel braced frame high rise
12	Steel frame with concrete walls low rise
13	Steel frame with concrete walls medium rise
14	Steel frame with concrete walls high rise
15	Steel frame with concrete infill walls
16	Steel frame with masonry infill walls
CONCRETE	
17	Concrete frame with concrete walls low rise
18	Concrete frame with concrete walls medium rise
19	Concrete frame with concrete walls high rise
20	Concrete moment frame low rise
21	Concrete moment frame medium rise
22	Concrete moment frame high rise
23	Concrete frame with infill walls

MASONRY	
24	Reinforced masonry shear wall low rise
25	Reinforced masonry shear wall medium rise
26	Unreinforced masonry bearing wall low rise
27	Unreinforced masonry bearing wall medium rise
CATEGORY/CLASS	**DESCRIPTION**
TILT UP	
28	Tilt up
PRECAST	
29	Precast concrete low rise
30	Precast concrete medium rise
MOBILE	
31	Mobile homes

Adapted from: Ventura et al., 2005, p. 376

- The BC PDBA Framework and Recommendations Appendix 2: PDBA Assessment Matrix draws on the UBC taxonomy to specify three categories of building type:

TYPE A, SPECIALISED/ HIGHLY COMPLEX	Reinforced Concrete Moment Resisting Frames (C1)-High-Rise (more than 8 stories)
	Concrete Shear Walls (C2) - High-Rise (more than 8 stories)
	Concrete Frame Buildings with Unreinforced Masonry Infill Walls (C3)-High-Rise (more than 8 stories)
	Precast Concrete Frames with Concrete Shear Walls (PC2)-High-Rise (more than 8 stories)
	Reinforced Masonry Bearing Walls with Precast Concrete Diaphragms (RM2) - High-Rise (more than 8 stories)
	Steel Moment Frame (S1) - High-Rise (more than 8 stories)
	Steel Braced Frame (S2) - High-Rise (more than 8 stories)
	Steel Frame with Cast-In-Place Concrete Shear Walls (S4) - High-Rise (more than 8 stories)
	Steel Frame with Unreinforced Masonry Infill Walls (S5)- High-Rise (more than 8 stories)
TYPE B (COMPLEX)	Reinforced Concrete Moment Resisting Frames (C1)-Low-Rise (range between 1 -3 stories)
	Reinforced Concrete Moment Resisting Frames (C1)- Mid-Rise (range between 4 -7 stories)
	Concrete Shear Walls (C2)- Low-Rise (range between 1 -3 stories)
	Concrete Shear Walls (C2)- Mid-Rise (range between 4 -7 stories)
	Concrete Frame Buildings with Unreinforced Masonry Infill Walls (C3)-Low-Rise (range between 1 -3
	Concrete Frame Buildings with Unreinforced Masonry Infill Walls (C3)-Mid-Rise (range between 4 -7
	Precast Concrete Tilt-Up Walls (PC1)

	Precast Concrete Frames with Concrete Shear Walls (PC2)-Low-Rise (range between 1 -3 stories)
	Precast Concrete Frames with Concrete Shear Walls (PC2)-Mid-Rise (range between 4 -7 stories)
	Reinforced Masonry Bearing Walls with Wood or Metal Deck Diaphragms (RM1)- Low-Rise (range between 1-3 stories)
	Reinforced Masonry Bearing Walls with Wood or Metal Deck Diaphragms (RM1)- Mid-Rise (more than 4 stories)
TYPE A, SPECIALISED/ HIGHLY COMPLEX	Reinforced Masonry Bearing Walls with Precast Concrete Diaphragms (RM2)- Low-Rise (range between 1-3 stories)
	Reinforced Masonry Bearing Walls with Precast Concrete Diaphragms (RM2)- Mid-Rise (range between 4 -7 stories)
	Steel Moment Frame (S1) - Low-Rise (range between 1 -3 stories)
	Steel Moment Frame (S1) - Mid-Rise (range between 4 -7 stories)
	Steel Braced Frame (S2) - Low-Rise (range between 1 -3 stories)
	Steel Braced Frame (S2) - Mid-Rise (range between 4 -7 stories)
	Steel Frame with Cast-In-Place Concrete Shear Walls (S4)- Low-Rise (range between 1 -3 stories)
	Steel Frame with Cast-In-Place Concrete Shear Walls (S4)- Mid-Rise (range between 4 -7 stories)
	Steel Frame with Unreinforced Masonry Infill Walls (S5)- Low-Rise (range between 1 -3 stories)
	Steel Frame with Unreinforced Masonry Infill Walls (S5)- Mid-Rise (range between 4 -7 stories)
	Unreinforced Masonry Bearing Walls (URM) - Low-Rise (range between 1 -2 stories)
	Unreinforced Masonry Bearing Walls (URM)- Mid-Rise (more than 3 stories)
	Reinforced Concrete Moment Resisting Frames (C1)-Low-Rise (range between 1 -3 stories)
	Reinforced Concrete Moment Resisting Frames (C1)- Mid-Rise (range between 4 -7 stories)
TYPE C (SIMPLE, NON-COMPLEX)	Wood, Light Frame (W1)
	Wood, Greater than 5,000 Sq. Ft. (W2)
	Wood Post & Beam
	Mobile Homes (MH)
	Steel Light Frame (S3)

Source: *BC PDBA Framework and Recommendations* Appendix 2: PDBA Assessment Matrix

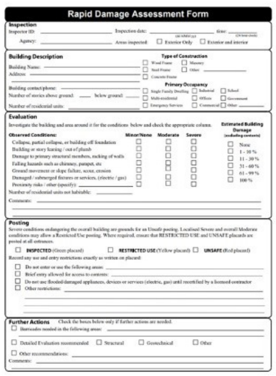
PDBA FORMS AND RESOURCES

This section includes PDBA forms and resources that are currently publicly available. Note that both these resources and the links to them will change over time. Please refer to the listed agencies and organizations for the most current material.

PDBA ASSESSMENT FORMS

BC HOUSING FORMS

Available at: https://www.bchousing.org/about/rapid-damage-assessment

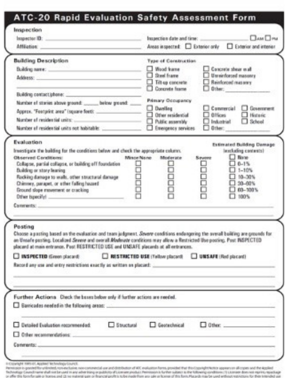

Rapid Damage Assessment Form

BC Housing Rapid Damage Assessment form

Available from: https://www.bchousing.org/about/rapid-damage-assessment

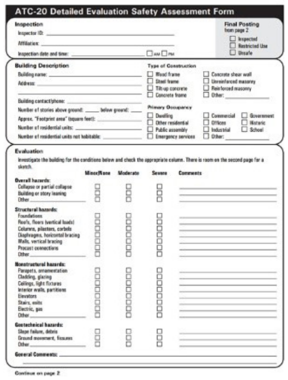
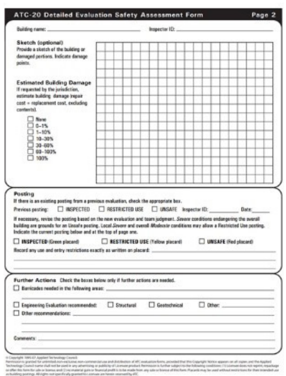
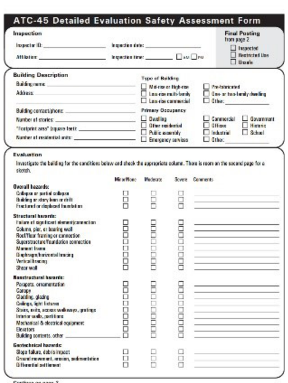
ATC FORMS

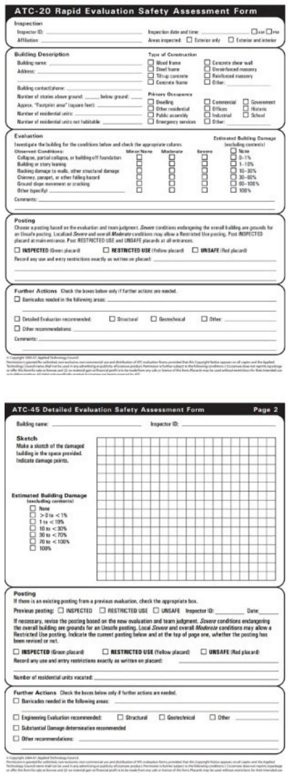
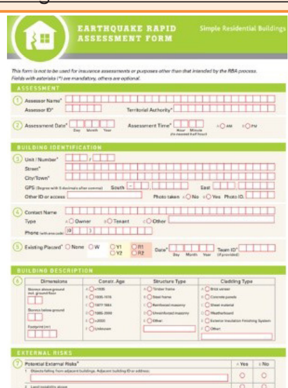
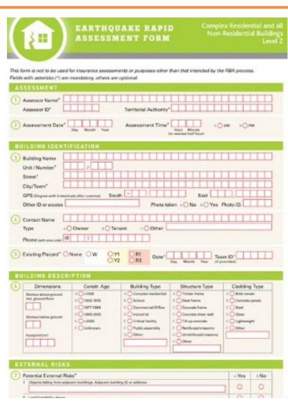
Available at: https://www.atcouncil.org/products/downloadable-products

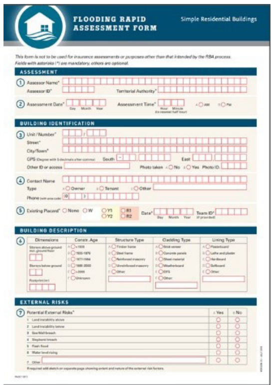
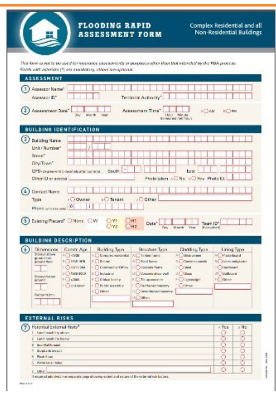
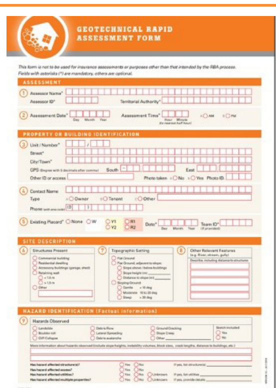
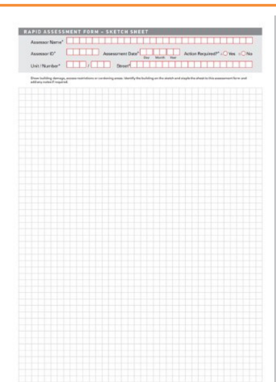

ATC-20 Rapid Evaluation Safety Assessment Form

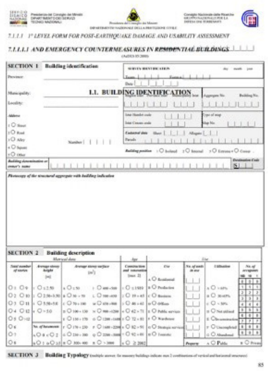
ATC 20-2 Rapid Evaluation Safety Assessment Form

Available from: https://www.atcouncil.org/pdfs/rapid.pdf

 ATC-20 Detailed Evaluation Safety Assessment Form  ATC-20 Detailed Evaluation Safety Assessment Form Page 2		ATC-20-2 Detailed Evaluation Safety Assessment Form Available at: https://www.atcouncil.org/pdfs/DETAIL.PDF
 ATC-20 Fixed Equipment Checklist		ATC-20 Fixed Equipment Checklist Available at: https://www.atcouncil.org/pdfs/ATC20FixedEquipment.pdf
 ATC-45 Detailed Evaluation Safety Assessment Form		ATC-45 Rapid Evaluation Safety Assessment Form Available at: http://www.atcouncil.org/pdfs/ATC45Rapid.pdf

		ATC-45 Detailed Evaluation Safety Assessment Form Available at: https://www.atcouncil.org/pdfs/ATC45Detail.pdf
NEW ZEALAND FORMS Available at: https://www.building.govt.nz/managing-buildings/post-emergency-building-assessment/field-guides-and-tools-for-building-assessment/#jumpto-rapid-assessment-process		
		NZ Earthquake: Simple Residential Buildings Form Available at: https://www.building.govt.nz/assets/Uploads/managing-buildings/post-emergency-building-assessment/earthquake-simple-residential-form.pdf
		Complex Residential and all Non-Residential Buildings – Level 2 Form Available at: https://www.building.govt.nz/assets/Uploads/managing-buildings/post-emergency-building-assessment/earthquake-non-residential-form-l2.pdf

		NZ Flooding: Simple Residential Buildings Available at: https://www.building.govt.nz/assets/Uploads/managing-buildings/post-emergency-building-assessment/flooding-rapid-assessment-form-residential-building.pdf
		NZ Flooding: Complex Residential and all Non-Residential Buildings Available at: https://www.building.govt.nz/assets/Uploads/managing-buildings/post-emergency-building-assessment/flooding-non-residential-form.pdf
		NZ Geotechnical Emergency Response Assessment Sheet Available at: https://www.building.govt.nz/assets/Uploads/managing-buildings/post-emergency-building-assessment/geotechnical-emergency-response-assessment.pdf
		NZ Rapid Assessment Sketch Sheet Available at: https://www.building.govt.nz/assets/Uploads/managing-buildings/post-emergency-building-assessment/rapid-assessment-sketch-sheet.pdf



AeDES Form

Note that the AeDES form is available as part of the Field Manual for post-earthquake damage and safety assessment and short term countermeasures (AeDES) (Baggio et al., 2007), available at: https://www.eeri.org/wp-content/uploads/Italy/EUR%2022868%20(2007)%20Field%20Manual%20for%20post-earthquake%20damage%20assessment.pdf

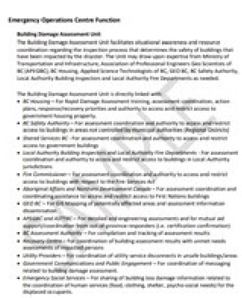
CALIFORNIA SAP RESOURCES

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

ADDITIONAL FORMS AND CHECKLISTS

BC HOUSING RAPID DAMAGE PROGRAM

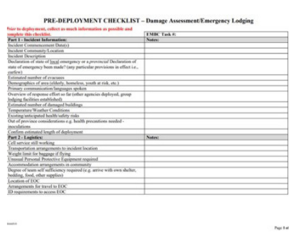
Additional downloads are available at: https://www.bchousing.org/about/rapid-damage-assessment



Emergency Operations Centre Function

Rapid Damage Assessment – Emergency Operations Centre Sample

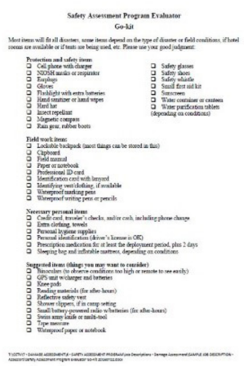
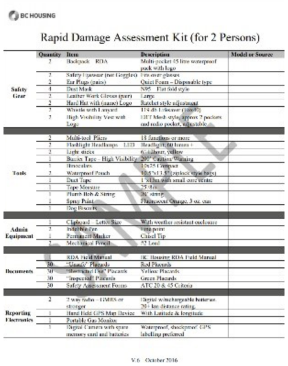
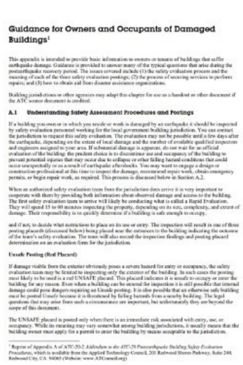
Available at: https://www.bchousing.org/publications/Rapid-Damage-Assessment-Emergency-Operations-Centre-Sample.pdf

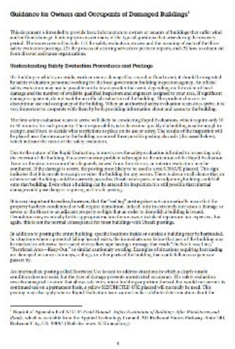
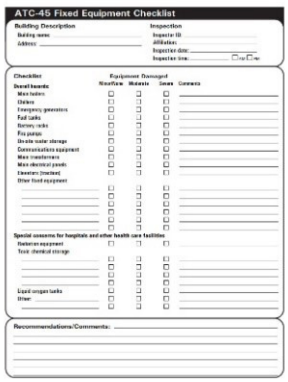


PRE-DEPLOYMENT CHECKLIST – Damage Assessment/Emergency Lodging

Pre-deployment Checklists - Damage Assessment and Emergency Lodging

Available at: https://www.bchousing.org/publications/Pre-Deployment-Checklist.pdf

 Safety Assessment Program Evaluator Go-kit		Safety Assessment Program Evaluator Go-kit Available at: https://www.bchousing.org/publications/Safety-Assessment-Program-Evaluator-Go-Kit.pdf
 Rapid Damage Assessment Kit (for 2 Persons)		Rapid Damage Assessment Kit (for 2 Persons) Available at: https://www.bchousing.org/publications/Rapid-Damage-Assessment-Kit.pdf
 Information for Building Owners/Occupants Regarding the Rapid Damage Inspection Of this Building		FAQ for Building Owners/Occupants Available at: https://www.bchousing.org/publications/Rapid-Damage-Building-Inspection-Placard-FAQs.pdf
ATC Additional downloads available at: https://www.atcouncil.org/products/downloadable-products/placards		
 Guidance for Owners and Occupants of Damaged Buildings[1]		ATC-20 Guidance for Owners and Occupants of Damaged Buildings Available at: https://www.atcouncil.org/pdfs/ATC202appendixA.pdf

 Guidance for Owners and Occupants of Damaged Buildings		ATC-45 Guidance for Owners and Occupants of Damaged Buildings Available at: https://www.atcouncil.org/pdfs/ATC45appendixE.pdf
 ATC-45 Fixed Equipment Checklist		ATC-45 Fixed Equipment Checklist Available at: https://www.atcouncil.org/pdfs/ATC45FixedEquipment.pdf

PDBA TRAINING

EXAMPLES OF PDBA EDUCATION AND TRAINING PROGRAMS

International groups provide a wide range of PDBA education and training programs. These range from short workshops/courses on conducting building assessment (e.g., based on ATC 20 or similar procedures) to comprehensive programs that integrate planning, administration, operations, and building assessment for dedicated teams or agencies (e.g., Italy, Greece, etc.). New Zealand has implemented a tiered training program with components for assessors, team leaders, and control/administration personnel.

The examples below range from 4 to 120 hours in duration:

- BC Housing
  - Assessor Training: 4 hours
  - Coordinator Training: 4 hours
- New Zealand
  - Structural Assessment training: 7 hours
  - Geotechnical Rapid Assessment training: 1 day (7 to 8 hours)
- ATC
  - ATC-20 Standard: 5 hours
  - ATC-20 SAP: 6 hours
  - ATC-20 and ATC-45: 7 hours
  - ATC-20 SAP and ATC-45: 1.5 days
- Gallagher et al., 2011: ATC 4 hours for structural engineers – focuses on performing assessments

- LessLoss (European Union)
  - Cyprus: 80 hours
  - Greece: 30 hours
  - Italy:
    - 40 hours
    - Longer course with broader focus 6 – 120 hours
  - Slovenia: 16 hours – 8 didactic and 8 practical

LINKS TO PDBA TRAINING

PDBA training varies substantially between countries and programs. Some countries, such as Italy and Greece, have national level Building Assessment programs with dedicated staff. In other countries, such as the USA, ATC-20 and ATC-45 form the foundation for training delivered through professional associations and PDBA programs. Examples of PDBA training includes the following:

- New Zealand has a comprehensive national network and training program to support PDBA. The program is maintained through NZ Ministry of Business, Innovation, and Education and is supported by key stakeholder groups.
  - The training program identifies three levels:
    - Tier 1: for those leading assessment operations
    - Tier 2: for senior building officials, structural and geotechnical engineers, and architects capable of leading local operations and field teams
    - Tier 3: for building officials, structural and geotechnical engineers, and architects who will function as assessors.
  - Information on New Zealand's Training Program is available at: https://www.building.govt.nz/managing-buildings/post-emergency-building-assessment/.
- ATC-20 and ATC-45 form the foundation for training in several PDBA systems, such as the California Safety Assessment Program (California Emergency Management Agency, 2012). For further information, please refer to the ATC website at https://www.atcouncil.org/products/training-info1.
- Information on the BC Housing Rapid Damage Assessment training is available at https://www.bchousing.org/about/rapid-damage-assessment.

03 ANNOTATED RESOURCES

INTRODUCTION

This section provides an annotated list of key and useful documents uncovered in the literature review for the BC PDBA applied research project. The section lists and describes particularly informative resources describing PDBA process from New Zealand, Italy, and Japan. These countries were selected for review based on recent major earthquake events requiring substantial post disaster building damage assessment.

Many of these documents provide similar information, though sometimes from different perspectives. Due to saturation of themes, not all documents are fully reviewed. Note that many of the documents reference each other and there is substantial overlap, particularly in regards to case history, BDSA procedures, issues, and recommendations.

NEW ZEALAND

In 2010 and 2011, the area in and around Christchurch Canterbury New Zealand experienced a series of earthquakes and aftershocks, the most significant of which occurred on 4 September, 2010, 26 December 2010, and 22 February, 2011. There was significant damage and substantial loss of life. There is a substantial body of work examining the response to the Canterbury earthquakes, including a Royal Commission. Significant changes were made to the New Zealand building assessment approach and processes.

Readers are directed to the following KEY Documents as essential reading on the Canterbury Earthquakes:

- Canterbury Earthquakes Royal Commission (2011). Discussion paper: Building management after earthquakes. CERC Christchurch, NZ.
- New Zealand Society for Earthquake Engineering. (2012). Building Management After Earthquakes: Submission to Canterbury Earthquakes Royal Commission. Wellington, NZ: NZSEE.
- Gallagher, R., Lizundia, B., & Barnes, J. C. (2011). Building Safety Evaluation after the February 22, 2011 Christchurch, New Zealand Earthquake: Observations by the ATC Reconnaissance Team. Redwood City, CA: Applied Technology Council.

ANNOTATED RESOURCES

Canterbury Earthquakes Royal Commission Document Library for Building Assessments http://canterbury.royalcommission.govt.nz/document-library?SearchView&Query=(Field+Subjects=%22Building+assessments+after+earthquakes%22)&Subject=Building+assessments+after+earthquakes	
Description	Documents from the Canterbury Earthquakes Royal Commission related to Building Damage Assessment.
Informs	All aspects
Commentary	Comprehensive set of documents that explores all facets of the Canterbury Earthquakes. Many of the documents listed in this review are taken from the site. Note that there are many documents that are not reviewed, even though there is relevance due to saturation – many of the reports reference each other, particularly in regards to case history, BDSA procedures, issues, and recommendations.
Canterbury Earthquakes Royal Commission (2011). Discussion paper: Building management after earthquakes. CERC Christchurch, NZ.	
Description	Discussion paper exploring "implementation and effectiveness of the building management process used after the 4 September and 26 December 2010 earthquakes." (p. 1). The intent of the paper was to generate discussion, identify lessons, and present some options for addressing issues raised in the paper.
Informs	BDSA processes generally NZ BDSA during CCC incidents Recommendations for changes to BDSA.
Commentary	This is a key document for understanding BDSA in the NZ context. The source has a substantial amount of core content, both on process, case, and recommendations. The recommendations are a KEY RESOURCE for the BC BDSA project.

New Zealand Society for Earthquake Engineering. (2012). *Building Management After Earthquakes: Submission to Canterbury Earthquakes Royal Commission.* Wellington, NZ: NZSEE.	
Description	Submission of the NZSEE to the Royal Commission. This submission is focussed largely on item b. above, i.e. the assessment of post earthquake building vulnerability: b. The vulnerability to damage of the buildings in the affected region may have been increased by earthquake effects,
Informs	Case Understanding decision-making rationale
Commentary	This is a key document. Many of the issues and recommendations are documented elsewhere. The discussion paper from p. 8 on discusses potential changes and rationale and is particularly useful for the next phases of this project.

Wilkinson, S., Grant, D., Williams, E., Paganoni, S., Fraser, S., Boon, D., Mason, A., & Free, M. (2013). Observations and implications of damage from the magnitude MW 6.3 Christchurch, New Zealand earthquake of 22 February, 2011. *Bulletin of Earthquake Engineering,* 23(11). 107-140.	
Description	Report of a reconnaissance team from UK-based Earthquake Engineering Field Investigation Team over 5 days following the 22 February 2011 incident. Article provides limited information on the case itself or BDSA procedures. Good discussion on the types of damage associated with specific types of buildings.
Informs	Building types taxonomy Examples of damage associated with specific types of buildings.

Gallagher, R., Lizundia, B., & Barnes, J. C. (2011). Building Safety Evaluation after the February 22, 2011 Christchurch, New Zealand Earthquake: Observations by the ATC Reconnaissance Team. Redwood City, CA: Applied Technology Council.	
Description	The Applied Technology Council (ATC) sent a small reconnaissance team to Christchurch, New Zealand to observe the building safety evaluation process following the Magnitude 6.2 February 22, 2011 earthquake. This report summarizes the reconnaissance team's observations, findings, and recommendations regarding postearthquake building safety evaluation. p. 1
Informs	Background on case Comparison of programs BDSA processes Indicator buildings Examples of building damage Recommendations
Commentary	Excellent comparison of then NZ procedures in comparison with ATC 20. Good discussion on BDSA processes. Excellent discussion on use of indicator buildings.

Ministry of Business, Innovation, and Employment. (2014). *Field Guide: Rapid Post Disaster Buildings Usability Assessment – Earthquakes.* Wellington, NZ: MBIE.	
Description	This guide replaces the document 'Building Safety Evaluation During a State of Emergency', published by the New Zealand Society for Earthquake Engineering (NZSEE) in August 2009. The experiences from the 2007 Gisborne earthquake, 2009 Padang earthquake, and 2010-2011 Canterbury earthquake sequence have also greatly assisted in updating this document.
Informs	BDSA Information Flow Specific assessments

Commentary	Key document. This is the revised version of NZ procedures based on the Canterbury experience. The level of detail is very useful and should be a good model for user-level stakeholders in the BC framework.
Ministry of Business, Innovation, and Employment. (2014). *Field Guide: Rapid Post Disaster Buildings Usability Assessment – Flooding*. Wellington, NZ: MBIE.	
Description	This Field Guide has been produced to assist building control officials, engineers, architects, property managers and other building professionals to carry out Rapid Building Usability Assessments during a State of Emergency. At the discretion of a territorial authority (TA) the Field Guide may be used outside a State of Emergency. This Field Guide is one of a suite of documents developed to promote a nationally consistent approach to rapid building usability assessments after the recommendations of the Canterbury Earthquakes Royal Commission.
Informs	BDSA Information Flow Specific assessments
Commentary	Key document. Companion to Earthquake guide – analyze for adaptation to flooding context.
McLean, I., Oughton, D., Ellis, S., Wakelin, B., & Rubin, C. B. (2012). *Review of the Civil Defence Emergency Management Response to the 22 February Canterbury Earthquake.* Wellington, NZ: Civil Defence and Emergency Management.	
Description	This review deals with the Civil Defence Emergency Management (CDEM) Response to the 22 February 2011 Canterbury earthquake, from the date of the earthquake until 30 April 2011. On that date the response phase officially ended and recovery process was taken over by the Canterbury Earthquake Recovery Authority (CERA). The purpose of the review is: _ from an emergency management perspective identify the practices that should be reinforced and identify the processes and policies that warrant improvements. p. 1
Informs	Narrative of the event from a political and organizational perspective. Good discussion on interplay between stakeholders.
Commentary	Commentary There is a lot of background in here. The recommendations are key, and there is lots of information on the decision-making and organizational processes involved in operationalizing BDSA. The list on p. 134 is a succinct summary of challenges from the NZSSE.
Middleton, D. & Westlake, R. (2011). Independent Review of the response to the Canterbury earthquake, 4 September, 2010. Wellington, NZ: Ministry of Civil Defence & Emergency Management.	
Description	Review of CDEM response to initial Sept earthquake. Note that report was not completed as review overtaken by subsequent aftershocks and events.
Commentary	Review itself has useful information, but not a lot that is new. Good description of response from CDEM perspective.

Canterbury District Health Board (2011). Canterbury Health System response to the independent review of the response to the Canterbury Earthquake, 4 September, 2010. Wellington, NZ: Canterbury District Health Board.	
Description	Report from BDHB in response to the independent report. Responds to particular elements of the initial report.
Commentary	Some information from perspective of CI – in this case health. Some information on multiple EOCs. Some information on information flow Some information on managing volunteers (need to).
Baird, A., Palermo, A., & Pampanin, S. (2011). Facade damage assessment of multi-storey buildings in the 2011 Christchurch earthquake. *Bulletin of the New Zealand Society for earthquake engineering,* 44(4), 368-376.	
Description	This paper presents the damage assessment of the façade systems of these RC buildings. A survey of 173 RC buildings in the Christchurch CBD is conducted here, focusing on the damage to the façade systems of the buildings.
Informs	Types of buildings Operational performance level
Commentary	Article deals with specific type of damage to specific structures in reinforced concrete buildings and is of limited value overall. However, there is some good general information on types of damage with reinforced concrete buildings. Section on operational performance level as a taxonomy of interest.
Lochhead, I. (2011). Christchurch architecture and the earthquakes of 4 September 2010 and 22 February 2011. Fabrications, 20(1), 120-127.	
Commentary	Good description of types of buildings in Christchurch and damage to specific buildings. Good narrative of the earthquake events.
Kam, W. Y., Pampanin, S., & Elwood, K. (2011). Seismic performance of reinforced concrete buildings in the 22 February Christchurch (Lyttleton) earthquake.	
Description	This paper describes observations of damage to reinforced concrete buildings from the September 2010 Darfield (Canterbury) earthquakes. Data was collated from first-hand earthquake reconnaissance observations by the authors, post-earthquake surveys, and communications and meetings with structural engineers in Christchurch. The paper discusses the general performance of several reinforced concrete building classes: pre-1976 low-rise, pre-1976 medium rise, modern low- and mid-rise, modern high-rise, industrial tilt-up buildings, advanced seismic systems and ground-failure induced damaged and retrofitted RC buildings.
Informs	Types of buildings damage to specific types of buildings
Commentary	May be useful for taxonomy of building types and examples of types of damage to specific buildings.
Lizundia, B., Hortacsu, A., & Gallagher, R. (2017). Improvements in Postearthquake Building Safety Evaluations: Lessons Learned From Recent Earthquakes.	
Description	This paper will reflect on lessons learned during recent development exercises, such as the development of an adaptation of the ATC-20-1 methodology for Bhutan which considered the country's vernacular buildings, made adjustments for its cultural and governmental context, and provided an extensive set of images of varying degrees and types of building damage with the recommended posting category.
Informs	Comparison of systems
Commentary	Supports several of previous sources.

ITALY

Italy maintains a robust national-level building assessment program due to the frequency of seismic events. The Italian program was reviewed based on its performance in managing several large-scale earthquakes, including the 2009 L'Aquila event. On April 6th, 2009, at 3:32 a.m., an earthquake of magnitude 5.9 on the Richter scale (Mw6.3) hit the city of L'Aquila, where about 73,000 people were living. It also affected some tens of municipality towns. The April 6 main shock and the subsequent severe aftershocks caused heavy and extensive damage in the urban area of L'Aquila as well as in several surrounding villages, mainly located in the south-eastern part of L'Aquila province. The most damaged ones were located SE of L'Aquila. The earthquake caused 309 victims, about 1,600 injured, more than 65,000 people needing assistance and about 30,000 long term homeless.

Readers are directed to the following KEY readings:

- Dolce, M., & Goretti, A. (2015). Building damage assessment after the 2009 Abruzzi earthquake. Bulletin of Earthquake Engineering, 13(8), 2241-2264.
- Goretti, A., & Di Pasquale, G. (2002, September). An overview of post-earthquake damage assessment in Italy. In EERI invitational workshop. An action plan to develop earthquake damage and loss data protocols, California.

ANNOTATED RESOURCES

Dolce, M., & Goretti, A. (2015). Building damage assessment after the 2009 Abruzzi earthquake. *Bulletin of Earthquake Engineering,* 13(8), 2241-2264.	
Description	The paper, after describing the procedures and the form that were used for the assessment, discusses the time evolution of the inspections and analyses the data on building type and seismic damage. The empirical damage distribution conditional upon seismic intensity and building type is provided and the role of several vulnerability factors, such as the quality of masonry, the construction year, the number of stories, and the pre-existing damage, is highlighted. Lastly the damage consequences, such as the immediate occupancy conditional upon building damage and building type, are reported. P.241
Informs	Case background Composition of teams Rationale for decision-making Use of process and forms – rationale and examples
Commentary	This is an excellent article and provides a comprehensive overview of a BDSA process in progress. Excellent description of the AeDES form and its criteria. Significant information on # teams, time per building, distribution of damage. NOT CODED, but excellent discussion on distribution of different types of damage (e.g., # A, # B, etc)
Goretti, A., & Di Pasquale, G. (2002, September). An overview of post-earthquake damage assessment in Italy. In *EERI invitational workshop. An action plan to develop earthquake damage and loss data protocols, California.*	
Description	The paper describes old and recent Italian experiences in the field of damage assessment, highlighting resolved, but also not yet resolved problems, that have been encountered in assessing procedures, forms, tools, computerisation, validation, maintenance, and data dissemination.
Informs	Historical aspects of damage assessment; damage assessment in relationship to larger/ other assessment activities; comparison of BDSA processes, albeit older.
Commentary	Excellent for overall discussion on BDSA and for historical development of BDSA in Italy. Nice comparison of systems, but all data is dated and several of the systems described have changed since this article was written. However, its structure and the elements it discusses are very useful. Not included in Italy Case or Program data extraction – will be covered in detail in the Comparison section

Goretti, A., Di Pasquale, G., & Rota, M. (2007). Analysis and reporting on state-of-the-art on post-earthquake safety and damage assessment. Lessloss Risk Mitigation for Earthquakes and Landslides Integrated Project. European Commission.	
Description	This report contains a state-of-the-art on post-earthquake safety and damage assessment procedures adopted in different European countries.
Informs	Overall procedures of BDSA Team composition Training Time on task Forms and information
Commentary	Brief, but relatively comprehensive overview of BDSA in Italy. Very useful document and probably has the most detailed description to date on Italian procedures.

Masi, A., Santarsiero, G., Digrisolo, A., Chiauzzi, L., & Manfredi, V. (2016). Procedures and experiences in the post-earthquake usability evaluation of ordinary buildings. Bollettino di Geofisica Teorica ed Applicata, 57(2).	
Description	In this study, after an overview of the survey forms adopted in several countries throughout the world, the form currently used in Italy for usability surveys (called the AeDES form) is described, especially focusing on those points that highlight the role of vulnerability in the final usability evaluation. An analysis of the extensive database of the L'Aquila 2009 earthquake usability surveys is presented, particularly discussing those buildings that were judged unusable despite having no or light damage. Finally, a case study analysed during the Emilia 2012 earthquake is reported. Masi, p. 200
Informs	Case background Use of non-credentialed personnel Building taxonomies
Commentary	Good discussion on history of damage assessment and development of current model. Discussion comparing BDSA models for Italy, Greece, US, NZ, Japan Break down of damage patterns for types of buildings (private, public, heritage) Building types (p. 207) – NOT CODED

Molinari, D., Menoni, S., Aronica, G. T., Ballio, F., Berni, N., Pandolfo, C., ... & Minucci, G. (2014). Ex post damage assessment: an Italian experience. *Natural Hazards and Earth System Sciences,* 14(4), 901.	
Description	This paper studies this context, and describes ongoing activities in the Umbria and Sicily regions of Italy intended to identifying new tools and procedures for flood damage data surveys and storage in the aftermath of floods. In the first part of the paper, the current procedures for data gathering in Italy are analysed. The analysis shows that the available knowledge does not enable the definition or validation of damage curves, as information is poor, fragmented, and inconsistent.
Informs	Flood damage assessment Higher order data management
Commentary	Good information on building assessment from a flooding perspective.

Baggio, C., Bernardini, A., Colozza, R., Corazza, L., Della Bella, M., Di Pasquale, G., ... & Papa, F. (2007). Field manual for post-earthquake damage and safety assessment and short term countermeasures (AeDES). E*uropean Commission—Joint Research Centre—Institute for the Protection and Security of the Citizen,* EUR, 22868.	
Description	This manual extends the Instructions reported on page 4 of the form, with the aim of providing a tool for a correct training of the surveyors and for a full awareness of the principles of the form, as well as for the necessary homogeneity of judgment. In Chapter 2, some information and guidelines on issues concerning the organisation of the damage and usability survey and the procedures for preparing and carrying out the building survey are given. Chapter 3 provides a detailed description of each structural component, correlating it to the building component behaviour (thrusting or non thrusting roofs, masonry of good or bad quality, rigid or flexible floors, etc.).
Informs	Definitions and discussion of usability Elements of a BDSA system p. 4 Building taxonomy p. 10.
Commentary	Detailed field guide for use of the AeDES form. Much of the information if structured in the context of completing the forms, making it difficult to extract for overall description of the BDSA process. The Manual does not describe the overall BDSA process.

Dolce, M., & Di Bucci, D. (2014). National Civil Protection Organization and technical activities in the 2012 Emilia earthquakes (Italy). *Bulletin of earthquake engineering,* 12(5), 2231-2253.	
Description	Description of NCPO response to Emilia earthquake in 2012
Informs	Some information decision making.
Commentary	Good overall description of broader earthquake assessment, with minimal information on actual BDSA procedures.

JAPAN

Japan is another country with a large number of seismic events and a comprehensive building damage assessment approach. However, the research team found only limited English-language literature.

ANNOTATED RESOURCES

Citation	Nakano, Y., Maeda, M., Kuramoto, H., & Murakami, M. (2004, August). Guideline for post-earthquake damage evaluation and rehabilitation of RC buildings in Japan. In 13th World Conference on Earthquake Engineering (No. 124).
Description	This paper describes the basic concept of the Guideline for Post-earthquake Damage Evaluation and Rehabilitation of RC Buildings in Japan. In this paper, (1) the damage rating procedure based on the residual seismic capacity index consistent with the Japanese Standard for Seismic Evaluation of Existing RC Buildings, (2) its validity through calibration with observed damage due to the 1995 Hyogoken- Nambu (Kobe) earthquake, and (3) the decision policy and criteria to determine necessary actions considering earthquake intensity and damage, are mainly focused. p. 1
Informs	BDSA for Reinforced Concrete buildings by "inspector engineer."
Commentary	Description and flowchart within the context of Reinforced Concrete buildings.

Seismic.ca.gov Table 1 – Comparison of Post-earthquake Building Evaluation Programs retrieved from: http://www.seismic.ca.gov/meeting_info/Item%20F3.2%20International%20Post-eq%20Comparison.pdf June 8, 2017	
Description	Comparison table from seismic.ca.gov site – unable to find link or source, although link is active. Comparison on BDSA programs from EU, Italy (AeDES), Japan, Greece, US (ATC 20), SEAOC (California)
Informs	Types of assessments Outcome categories Placard use Use of form Time per inspection # trained assessors Liability protection
Commentary	NOTE _ UNABLE TO VERIFY OR VALIDATE INFORMATION. Very useful document, but cannot verify. Do not know when table was compiled, or by whom, or from what document.
Isoda, K. (1995). Issues to be Solved in the Establishment of Institution of Assessing the Safety of Damaged Buildings in Japan. 8th International Research and Training Seminar on Regional Development Planning for Disaster Prevention Emergency Assessment System of Damaged Buildings.	
Description	Presentation given in 1995 as part of the Proceedings of the 8th International Research and Training Seminar on Regional Development Planning for Disaster Prevention 16 January 1995 Osaka, Japan
Informs	Limited information on personnel and categories of outcome for BDSA in 1990s.
Commentary	Presentation gives some peripheral information. Dated – from 1995.
Saito, T., & Thakur, S. K. (2012). Post-Earthquake Quick Risk Inspection System for Buildings. Available at: http://canterbury.royalcommission.govt.nz/documents-by-key/20120614.4541/$File/ENG.KACST.0001.pdf	
Description	This document provides a description of the Japan quick inspection system and a comparison of several other international programs.
Informs	Types of assessments Outcome categories Placard use Use of form Program structure and administration
Commentary	Very useful document. Sourced through the Canterbury Royal Commission site. Unable to locate original source.
Saito, T. (2007, August). Disaster management of local government in Japan. I*n National Workshop, organized by UNCRD and Japan-Peru Center for Seismic Research and Disaster Mitigation (CISMID)/Peru National University of Engineering (UNI).*	
Description	An earlier version of the Saito & Thakur paper, above. Similar content.
Informs	Types of assessments Outcome categories Placard use Use of form Program structure and administration
Commentary	Brief but useful information describing the quick inspection system in Japan.

04

REFERENCES AND RESOURCES

This section contains references to academic and professional literature and to documents and presentations that were encountered in the development of the BC PDBA Framework and Recommendations. Note that many of these resources have been updated by the host organizations and agencies. In addition, the references include older information and information.

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Canterbury Earthquakes Royal Commission Document Library for Building Assessments

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