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REVIEWING AND ENHANCING FLOOD DAMAGE ASSESSMENT METHODOLOGIES IN NEW ZEALAND

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ABSTRACT: This study investigates current methodologies used for post-flood building assessments in New Zealand and compares them with those used in the United States. It identifies gaps in these approaches and proposes potential improvements. It highlights the critical need for updated guidelines due to the increasing frequency of floods associated with climate change. Recent flooding events, including the significant North Island flood in 2023, underscore the urgency for improved methodologies to expedite recovery efforts.

KEYWORDS: flooding, timber construction, flood damage assessment, detailed evaluation

1 – INTRODUCTION

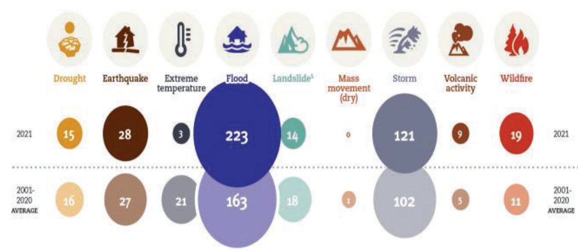
New Zealand has been experiencing an increasing number of severe weather events due to climate change, including floods that result in significant damage. This document outlines the current definitions and practices for post-flood building assessments in New Zealand. It discusses the essential elements of evaluation, provides an overview of current best practices, and identifies gaps in the field. It also highlights the need for updated guidelines to facilitate efficient reconstruction planning and recovery times. Recommendations will be provided to improve the flood damage assessment process.

2 – BACKGROUND

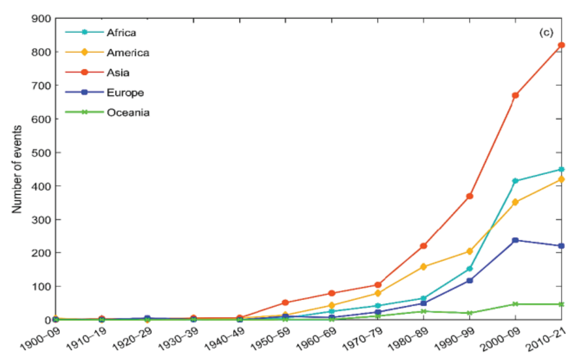
Climate change has become a growing concern due to its link to extreme weather events, which can damage buildings, bridges, and other infrastructure. Global warming causes frequent changes in climate factors across all regions. The Intergovernmental Panel on Climate Change (IPCC) has highlighted the escalating pattern of climate change, predicting more intense heat waves, heavy rainfall, and flooding events across many regions [1].

Various types of flooding constitute a significant portion of natural catastrophe events, and their increasing frequency highlights the importance of preparedness and planning [2]. According to the Federal Emergency Management Agency (FEMA), disaster declaration data from May 2, 1953, to March 3, 2019, indicates that floods are the most common type of natural disaster, representing 40.46% of total disaster declarations [3].

Flooding events were the most frequent disasters worldwide, with 223 recorded occurrences in 2021 alone. This number is significantly higher than the total number of flood disasters documented in the previous ten years, as shown in Fig.1a. The rising trend in flood events across different continents is illustrated in Fig.1b [4].



(a)



(b)

Figure 1: *Comparison of occurrences a) Types and frequency of disasters in 2021 compared to the annual average from 2001 to 2020 [5]; b) number of major floods reported in each continent since 1900 [4].*

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New Zealand has experienced several extreme weather events in recent years which cost New Zealanders millions of dollars [6]. Flooding occurs frequently in New Zealand due to its geography as a collection of small islands in the "roaring forties," an area known for intense rainfall. Climate change has also increased the intensity and frequency of rainfall and flooding. On average, there is a significant flood every eight months [7]. Table 1 provides detailed information on the latest flood-related natural disasters in New Zealand since 2021 and the expense of compensating claims for those events to the insurance sector. The prices in this table have been updated to reflect inflation as of June 30, 2023 [6].

Table 1: *Financial costs of flood-related disasters in New Zealand [6]*

Date	Event	Cost ($ million)
2023 Jan 27–Feb 02	Auckland Anniversary Weekend to 1 Mar 2024	2016.6
2022 Aug 18-21	Remainder of New Zealand (incl. Marlborough)	38.5
2022 Aug 18-21	Nelson-Tasman Flooding	32.6
2022 Mar 21-29	North Island Floods	129.2
2021 Nov 3-5	Gisborne Floods	3.7
2021 Aug 30-31	West Auckland Flooding	69.8
2021 Jul 16-19	West Coast Flooding	110.2
2021 Jul 16-19	Wellington Floods	20.3
2021 Jul 16-19	Upper South Island Floods	19.7
2021 Jul 16-19	North Island Floods (excluding Wellington)	9.1
2021 May 29-Jun 1	Canterbury Flooding	53.1

According to the Insurance Council of New Zealand (ICNZ), the recent North Island flood is likely the country’s largest-ever non-earthquake insurance event. This flood event, marked by over 50,000 claims, represents the most significant weather-related claims event on record [6],[8]. Despite the availability of insurance, flooding still causes extensive damage to homes and businesses. Following the event, Auckland Council’s building consent team immediately initiated rapid building assessments. They have completed a total of 4,991 assessments. As of 06 February, 273 homes were determined to be unsafe for habitation, 1,556 homes were severely damaged, and 2,469 homes were reported to have minor damage [9].

The significant weaknesses in the city's emergency management system for severe events have been highlighted in the Auckland Flood Response Review. It specifically pointed out shortcomings in leadership and communication protocols during the critical early stages. These issues not only compromised public confidence but also reduced the effectiveness of the response efforts. Systemic improvements are needed to ensure a more resilient and effective management of future emergencies [10].

Disaster or emergency management aims to minimize both the immediate and long-term impacts of a disaster event. It includes actions taken before, during and after a disaster [11]. Current flood damage assessment methodologies in New Zealand, lack specific guidelines for various construction types. The lack of specific assessment guidelines for timber framing complicates damage evaluations and may delay the rehabilitation of these structures, highlighting the need for improved methodologies to address this issue. According to the Building Research Association of New Zealand (BRANZ), a significant portion of residential buildings in New Zealand are constructed using light timber framing (LTF) [12]. Timber framing is the dominant form of construction, accounting for more than 90% of the market for residential buildings [13].

Paulik et al. studied residential buildings affected by five major flood events in New Zealand between April 2013 and April 2017. Their study categorized the flood-damaged residential buildings into 12 typology classes based on their construction period and physical attributes, including construction type, floor type, and number of storeys. These classes represent common building component materials and sizes used in New Zealand (refer to Table 2). The results showed that timber-frame buildings accounted for 98% of the damage sample. More than 75% of these buildings were constructed before 2000 and were typically single-storey structures built on pile foundations [14].

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Table 2: Types of residential buildings affected by five recent flood events [14]

Building Typology	Construction Type	Foundation Type	Storeys	Period of Construction (Year)	Damage Samples	Percentage (%)
Class 1	Timber	Pile	1	<1960	258	38.3
Class 2	Timber	Pile	2	<1960	6	0.9
Class 3	Timber	Pile	1	1960 < 2000	256	38
Class 4	Timber	Pile	2	1960 < 2000	23	3.4
Class 5	Timber	Pile	1	> 2000	13	1.9
Class 6	Timber	Pile	2	> 2000	1	0.1
Class 7	Timber	Concrete Slab	1	1960 < 2000	53	7.9
Class 8	Timber	Concrete Slab	2	1960 < 2000	10	1.5
Class 9	Timber	Concrete Slab	1	> 2000	40	5.9
Class 10	Timber	Concrete Slab	2	> 2000	1	0.1
Class 11	Concrete Masonry	Concrete Slab	1	-	9	1.3
Class 12	Concrete Masonry	Concrete Slab	2	-	4	0.6
Total					674	100

3 – PROJECT DESCRIPTION

Following an event that causes widespread damage, many buildings may become hazardous due to risks of collapse, falling debris, disrupted services, unsanitary conditions, and additional related dangers. After an incident, trained professionals assess damaged or potentially damaged buildings to evaluate their safety and habitability for continued use. These evaluations determine whether occupants can safely re-enter the buildings or if access should be restricted or prohibited, prioritizing occupant safety while facilitating both short-term and long-term recovery plans [3].

Although the fundamental elements of these evaluations are universal, this project aims to review the existing framework for post-flood building assessments, focusing on practices in New Zealand and comparing them with those in the United States.

3.1 NEW ZEALAND

A range of assessments and evaluations is necessary after a flood event, including rapid impact assessments, rapid building assessments, interim use evaluations, and detailed damage evaluations [15].

Assessing the impact of an emergency is crucial for effective response planning and the implementation of immediate response activities. There are two types of rapid impact assessment: initial situation overview and initial damage assessment. They are based on the first two levels of the New Zealand Fire Service Urban Search and Rescue (USAR) assessments.

The initial situation overview is carried out within the first 8 hours after an emergency to assess the extent of the damage quickly. This assessment may involve a drive-by, walk-by, aerial survey, or a combination of these methods. The collected information will help determine the immediate actions and resources needed to respond to the emergency's effects. The initial damage assessment is usually conducted within 48 hours following a disaster. In this assessment, a further phase of data collection will be conducted to obtain more detailed street-level data following the initial overview. It provides essential information that local authorities, Civil Defence Emergency Management (CDEM) Groups, and national agencies use to identify areas that need more evaluations, such as assessments of buildings or welfare needs. Additionally, it helps determine the requirements for short-term assistance and prepares an initial estimate of the disaster's costs. The four main phases of impact assessments are the same for both parts of rapid impact assessments: prioritising and preparing, collecting information, analysing information, and disseminating information. However, the key differences between the two are in the time taken and the level of detail required [16].

The impact of observed damage on the ongoing use of a building or adjacent property is evaluated during the rapid building assessment. Once a state of emergency is declared, territorial authorities will carry out this stage. During this stage, assessors will evaluate the type of damage and its impact on the building's structural integrity (or part of it) to withstand reasonably foreseeable actions, such as normal rainfall, everyday service loads, and loads from wind or snow. The Ministry of Business, Innovation, and Employment (MBIE) has published a field guide for flooding events. This guide provides a framework for rapid building assessments during a state of emergency or transition period. Its scope covers the period from the completion of the initial

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impact assessment until the emergency declaration is lifted; detailed assessments beyond this point are not included.

The document titled 'Rapid post disaster building usability assessment – flooding' by MBIE provides rapid assessment forms and general instructions for evaluating residential and non-residential buildings. The assessments include both external and internal inspections, which usually take between 30 minutes to 2 hours to complete for each building. Based on the initial findings, a placard is placed to indicate the building's condition. This placard specifies whether the building is safe for use, requires restricted access, or should not be entered at all. The following table illustrates the various levels of rapid assessment outcomes and their corresponding placards. To ensure safety and provide clear information, barrier tape may be utilized around the building. Additionally, an information sheet outlining the assessment findings and any necessary precautions or next steps will be given to the building's owner or occupant [15].

Table 3: *Rapid Assessment placards [3]*

Observed damage	**Residential Rapid Assessment outcome**	**Placard**
Light or no damage (Low risk)	No immediate further evaluation required	
Moderate damage (Medium risk)	No entry to parts of building with significant damage	
	Entry restricted to removal of contents and securing work	
Heavy damage (High risk)	At risk from external factors such as adjacent buildings or from ground failure	
	Significant damage	

It's important to note that a building marked with a white placard does not necessarily mean it is completely safe or that no damage has been found. Some damage may exist that does not pose an immediate risk to public safety. This can include issues such as the loss of services like plumbing or potable water supply, damage to interior finishes that do not affect structural integrity, and cracks in the plaster on exterior walls that do not create a falling hazard. The white placard only signifies that no major damage has been identified, and the building may be considered safe. The Interim Use Evaluation (IUE) and Detailed Damage Evaluation (DDE) are carried out during or after a declared state of emergency or transition period by engineers who are contracted by building owners or tenants. The assigned engineers must make their own decisions based on a complete assessment rather than relying on the rapid assessment results, which are meant to be used only as a guide. During these evaluations, the vertical and lateral load-resisting systems are assessed to ensure the continued safe use of the buildings. All necessary repairs and reinforcements are identified for comprehensive recovery and future safety. However, there is no framework to assess buildings and determine the repair requirements. The absence of detailed protocols for assessing damaged timber frame structures leads to inconsistent practices, even for similar structures [15], [17].

BRANZ Bulletin 666, 'Restoring a Home After Flood Damage,' provides guidelines for the remediation and restoration of homes in New Zealand following flood damage. It has updated and replaced Bulletin 455 [18], incorporating lessons learned since the earlier publication and adapting to more recent building regulations and standards.

Before starting any restoration work, it is essential to obtain permission from local authorities or civil defence emergency management. In BRANZ Bulletin 666, the first step is ensuring the building is safe to enter, followed by a thorough cleaning and drying phase before any repairs start. This document focuses on the restoration process rather than on making properties flood resistant. It highlights the complexities involved in recovering from floods and outlines the risks that come with delayed repairs. These risks include health hazards due to a damp environment and potential structural deterioration. While the bulletin acknowledges the necessity of evaluating timber structures, it falls short of providing precise standards and instructions for evaluating and repairing damage unique to timber-frame buildings [19].

3.2 THE UNITED STATES

Federal Emergency Management Agency (FEMA) Preliminary Damage Assessment (PDA) Guide is a standard framework designed to ensure recovery assistance for natural disasters, including floods. There are two types of PDAs: Initial Damage Assessments (IDAs) and Joint Preliminary Damage Assessments (Joint PDAs). IDAs are coordinated by local authorities to collect data related to the extent of damage within a jurisdiction, while Joint PDAs involve collaboration

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among local, state, and federal authorities to validate the damage data collected earlier. This validation supports requests for Presidential disaster declarations and determine eligibility for federal disaster grants. The Joint PDAs are initiated by request, not automatically. FEMA has categorized damage to impacted homes into four degrees: destroyed, major, minor, and affected. General descriptions of flood damages for these four categories are provided; however, they are not construction-type specific [20].

According to the *FEMA P-2055: Post-Disaster Building Safety Evaluation Guidance* (2019), the objective of post-disaster evaluations is to assess both the structural integrity and habitability of buildings following an incident to ensure public safety and support recovery efforts. These evaluations are categorized into four types, including very broad windshield evaluations, rapid evaluations, more detailed evaluations, and engineering evaluations. The process begins with a windshield survey which is conducted by building officials or emergency response managers to determine the nature and extent of building damage and prioritize areas before sending evaluation teams to the field. Based on these findings, rapid evaluations are performed on buildings, typically taking about 30 minutes each. These evaluations help identify buildings that require more detailed evaluations or necessary restrictions. A detailed evaluation will be conducted if a building is identified as requiring further inspection. This process involves a careful visual examination of the building and its structural system. Typically, this evaluation takes one to four hours per building. The Applied Technology Council (ATC) – 45 Field Manual was published in 2004 and provides procedures and forms used for the rapid and detailed evaluations of flood-damaged buildings. Qualified professionals use this manual to conduct on-site evaluations that lead to the posting of placards. The ATC-45 methodologies focus on evaluating buildings to determine whether a windstorm or flood has compromised their strength, stiffness, or stability. A fourth level of evaluation, known as an Engineering Evaluation, is briefly defined in ATC-45, although it is not discussed in detail. This evaluation is performed by structural engineering, geotechnical, or hydrologic consultants hired by the owner [21], [3].

Engineering evaluation is the most comprehensive type of evaluation and involves a detailed engineering investigation of damaged buildings. It includes using construction drawings, damage data, and new structural calculations. These evaluations are used to determine the appropriate repair methods for the building [3].

FEMA also developed the Substantial Damage Estimator (SDE) Tool, which allows the damage estimation in percentages for residential and non-residential structures, including timber frame buildings. Substantial damage occurs when a structure is damaged, and the cost to repair it to its original condition is 50 percent or more of its market value before the damage. The substantial damage determinations in accordance with the National Flood Insurance Program (NFIP) regulations can be conducted using the FEMA SDE tool. The necessary data for making these determinations is identified within the tool. This tool simplifies and standardizes the damage assessment process, making evaluations faster and more consistent across different situations.

4 – CONCLUSIONS AND RECOMMENDATIONS

While New Zealand's guidelines focus heavily on rapid response, FEMA has provided a more comprehensive framework that integrates both immediate and long-term recovery needs. Considering the importance of timber in New Zealand's construction industry, it is imperative to improve its methodology to incorporate precise, data-based guidelines specifically for timber structures. Such revisions would enhance the accuracy and reliability of post-flood evaluations for timber frames, facilitating more effective assessment and repair processes.

Following a flood event, the current best practice is to use the field guide titled 'Rapid post disaster building usability assessment – flooding' [15]. This field guide provides information for rapid impact assessments and rapid building assessments. Engineers contracted by building owners are responsible for conducting the interim use and detailed damage assessments. These evaluators may have different levels of experience and training, which affects the quality of evaluations. More detailed guidance and protocols for these stages are needed considering building types such as light timber frame constructions.

Currently, there are no best practice guidelines for evaluating building safety after multi-hazard incidents. It would be beneficial to create a culture of awareness within the response community, recognizing that the primary incident may not be the only event and may not be the most destructive or impactful. FEMA highlights the need to address secondary events such as dam failures caused by floods or landslides led by earthquakes. These secondary events can sometimes be more destructive than the initial disaster, affecting infrastructure, habitability, and recovery timelines [3]. Developing a comprehensive framework to evaluate safety under multi-hazard conditions would improve preparedness and response efforts.

Adopting a tool similar to FEMA's Substantial Damage Estimator (SDE) can be considered to support local authorities in assessing and managing substantial damage determinations. This would help ensure consistent post-disaster rebuilding practices.

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