The impacts of building code amendments in New Zealand

Amarachukwu Nnadozie Nwadike

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Construction

Massey University
Auckland, New Zealand

April 2021

Copyright

Abstract

The performance of buildings during earthquake-related disasters in the New Zealand built environment indicates that the New Zealand building code needs improvement to ensure that impacts of future earthquakes would be minimised. The level of destruction has triggered building code, standards, and compliance document amendments to improve building resilience against natural disasters such as an earthquake and other related extreme loading conditions. The building code has been amended; however, using the revised building code, standards, and compliance documents comes with its unique challenges to the entire system. This thesis explores the impacts of building code amendments in New Zealand's built environment. Before this study, there is no previous research on the impacts of regular building code amendments, their advantages, unintended consequences, compliance and ways of improvements with adequate recommendations in New Zealand.

The thesis proposes to address the impacts of building code amendment by identifying and exploring the benefits, effects of innovative techniques, compliance and unintended consequences of building code amendment. The thesis also investigates the factors that contribute to building code compliance challenges, the amendment process, and developing a framework that allows for stakeholder's inclusiveness to increase the level of building code compliance.

This thesis involved a mixed research method comprising qualitative and quantitative research to answer the research questions that justify the objectives

of this thesis. The mixed research methods include questionnaires, document analysis, interview with subject matter experts, narrative and integrative literature reviews. The study findings show that building code amendments in New Zealand have yielded significant results with emphasis on improved building resilience, increased compliance level, improved flexibility in design and construction, improved the quality of construction materials, increased professional training, and reduced corruption tendencies. Accordingly, the study addressed the efficacy of building code amendments as a measure to reduce the impact of disasters while increasing the built environment resilience.

The thesis revealed the effectiveness of consultation with all relevant stakeholders in building a regulatory system, free access to amended documents with support for a three years amendment cycle, as against the current biannual amendment practised in New Zealand. The unintended consequences of building code amendments are primarily influenced by (i) passive training of code users, (ii) bureaucracy, (iii) shortage of competent technical staff, and (iv) increased building code complexities.

The thesis developed a framework design based on identified parameters that assist in improving building code. The parameters consist of five action priority features such as regulation and administration, design and implementation, enforcement, compliance, and amendment process. The thesis developed an evidence-based framework that balances the diversity of stakeholder's interest and enhances the building code improvement. The findings from the evidence-based framework validation show that it can facilitate a robust building code

improvement with a well-defined area of priority while providing a better understanding of the code requirements and technical assistance to the code users.

The study provides useful recommendations that require an implementation to improve building resilience, performance-based building code, encourage building code compliance, reduce the unintentional consequences of building code amendment and help the stakeholders to comply with building code. The thesis demonstrates that the unforeseen negative impacts of building code amendment can be effectively handled through the intervention of the building regulatory authorities, proactive government response and collaboration with the stakeholders. This research is significant as it contributes to the theoretical understanding of building code, its amendment and regulatory system as a measure to reduce the impact of disasters. The study also contributes to the decision-makers within the building regulatory system as it informs the building policy regulators on the importance of systematic training of code users and balancing of the innovative techniques in performance-based building code with the safety measures in amending the New Zealand building code. The findings in this thesis may not be generalised but could be transferred globally to the nations that regularly review and updates their performance-based building code, standards and other related compliance documents within the range of New Zealand building code amendment interval.

Dedication

To the only wise God my saviour Jesus Christ who surrounds me with His unfailing love, mercy, grace, knowledge, righteousness and hold my hands at all time, even when I am not qualified.

"For God so loved the world, that he gave his only begotten Son, that whosoever believeth in him should not perish, but have everlasting life." (John 3:16)

To my family that never stops to support and pray for me at all times

Acknowledgements

I am sincerely indebted to the almighty God who gave me the strength, knowledge, understanding, wisdom and enabling environment during the cause of my PhD research.

My gratitude goes to my wonderful family, especially my parents Mr and Mrs E. U. Nwadike and my lovely siblings (Ngozi Nwadike, Nnamdi Nwadike, Ugochi Nwadike, Kelechi Nwadike, Chidibere Nwadike, Nmasinachi Obiyor), and their respective families for their financial support, encouragement and prayers. My PhD research would not have been complete without your supports, sacrifices and inspirations that hard work leads to success.

My sincere appreciation to my primary supervisor Professor Suzanne Wilkinson Jane, for her excellent guidance, financial support, encouragement, advice, constructive feedbacks and enabling environment during this research period. I count myself privileged to be supervised under her wealth of knowledge. Words are not good enough to express my appreciations. Also, I am most thankful to Professor Suzanne for sponsoring the presentation of my research work at an international scale in the USA, Canada and beyond. I humbly appreciate professor Charles who was my co-supervisor but later could not continue due to circumstances beyond his control. I am delighted to acknowledge my co-supervisor, Associate Professor James Rotimi, for his support and guidance during my PhD journey.

I am grateful to the entire staff and management of the School of Built Environment, Massey University, Auckland, for providing me with all necessary learning resources, financial assistance through my research account, and a scholarship through the help of my primary supervisor, Professor Suzanne Wilkinson. My appreciation also goes out to the staff and management of the University of Auckland's Civil Engineering department for the provision of learning resources and financial support through my student's PRESS account at the start of my PhD pursuit in New Zealand.

Finally, I wholeheartedly appreciate my PhD colleagues Osamuede Odiase, Olabode Ayodele, Israel Atakulu, Niransha Rodrigo, Uchenna Madu and most importantly, to my best friend Esther Itohan Aigwi, for their tremendous support and encouragement at all times. Words can not describe my gratitude to the Osamuede Odiase family for their warm welcome when I arrived in New Zealand.

Table of Content

List of Figures

List of Tables

Abbreviations and acronyms

BA	Building Act
IBM	International Business Machines
MBIE	Ministry of Business, Innovation and Employment
NZ	New Zealand
NZSEE	New Zealand Society for Earthquake Engineering
PIS	Participant Information Sheet
RO	Research Objective
RQ	Research Question
SPSS	Statistical Package for Social Sciences
UK	United Kingdom
NZBC	New Zealand Building Code
SME	Subject Matter Experts
BCA	Building Code Amendment
NCC	National Construction Code
OECD	Organisation for Economic Co-operation and Development
USA	United States of America
UK	United Kingdom

IBHS	Institute for Business and Homes Safety
NCBCS	National Council on Building Codes and Standards
AMUBC	Australian Model Uniform Building Codel
IBC	International Building Code
ICC	International Code Council
USSR	Union of Soviet Socialist Republics
BC	Building Code
IAPMO	International Association of Plumbing and Mechanical Officials
NFPA	National Fire Protection Association
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineer
CF	Consent Form
CERC	Canterbury Earthquake Royal Commission
Mw	Moment Magnitude
UNISDR	United Nations Office for Disaster Risk Reduction
JICA	Japan International Cooperation Agency
USAID	United States Agency for International Development
ABCB	Australian Building Codes Board
IRC	Institute for Research Construction
BCA's	Building Consent Authorities

BRANZ	Building Research Association of New Zealand
CCANZ	Council of Churches in Aotearoa/New Zealand
SESOC	Structural Engineering Society New Zealand
HERA	Heavy Engineering Research Association
SCNZ	Shipping Corporation of New Zealand
M	Mean Value
SD	Standard Deviation
UNECE	United Nations Economic Commission for Europe
CSSE	California Seismic Safety Commission
UNDP	United Nations Development Programme
BNBC	Bangladesh National Building Code
BHRRC	Business and Human Right Resource Centre
APN	Asia-Pacific Network for Global Change Research
DBH	Department of Building and Housing
GBPN	Global Buildings Performance Network
FEMA	Federal Emergency Management Agency
BAP	Building Advisory Panel

List of peer-reviewed publications

1) **Nwadike, A.**, Wilkinson, S., & Clifton, C. (2019). Comparative Insight on Building Code Paradigm Shift Practice and Updates: International Perspectives. The 4th International Conference on Civil, Structural and Transportation Engineering (ICCSTE' 19), Ottawa, Canada – June 11 – 12, 2019. Paper No.: ICCSTE 143, DOI: 10.11159/iccste19.143
2) **Nwadike, A.**, & Wilkinson, S. (2020). Impacts of innovation in performance-based building code. New Zealand Society for Earthquake Engineering (NZSEE) Annual Technical conference 2020.
3) **Nwadike, A.,** Wilkinson, S., & Clifton, C. (2020). Building code amendment process: A case study of New Zealand. The 9th International Conference on Building Resilience (ICBR 09), Bali, Indonesia, January 13 – 15, 2020. Paper No.: 201.
4) **Nwadike, A.,** & Wilkinson, S. (2020). Building code amendment and building resilience: Perspective of building code users in New Zealand. *Built Environment Project and Asset Management.* DOI: https://doi.org/10.1108/BEPAM-02-2020-0020
5) **Nwadike, A.,** & Wilkinson, S. (2020). Why amending building codes? An investigation of the benefits of regular building code amendment in New Zealand. *International Journal of Building Pathology and Adaptation.* DOI:https://doi.org/10.1108/IJBPA-08-2020-0068.

6) **Nwadike, A.,** & Wilkinson, S. (2020). Unintended consequences of building code amendment in New Zealand. Journal of Performance of *Constructed Facilities [Under review].*

7) **Nwadike, A.,** & Wilkinson, S. (2020). Challenges facing building code compliance in New Zealand. *Published in International Journal of Construction Management.* DOI:10.1080/15623599.2020.1801336.

8) **Nwadike, A.,** Wilkinson, S., & Clifton, C. (2019). Improving disaster resilience through effective building code compliance. *Published in the proceeding's of 2019 international i-Rec conference, Florida, United States of America.*

9) **Nwadike, A.,** & Wilkinson, S. (2020). Promoting performance-based building code compliance in New Zealand. *Journal of Performance of Constructed Facilities. DOI: 10.1061/(ASCE)CF.1943-5509.0001603*

10) **Nwadike, A.,** & Wilkinson, S. (2020). Identification of parameters to develop a theoretical framework to improve building code amendment in New Zealand. *The 54th International Conference of the Architectural Science Association (ANZAScA) 2020.*

11) **Nwadike, A.,** & Wilkinson, S. (2020). An evidence-based framework for building code improvement in New Zealand. *Engineering, Construction and Architectural Management.* https://doi.org/10.1108/ECAM-08-2020-0604.

1. Introduction

1.1. Background

The frequency of disaster occurrence has continuously increased over the years despite all efforts to reduce its impacts in the built environment. The magnitude of disaster destruction presents numerous challenges to the built environment regarding mitigation strategies to improve building resilience. The destructive impacts of disaster emerge in various forms that exacerbates the situation and undermine the limited achievements made globally to reduce the disaster impacts in the built environment. Within the context of this study, disaster-prone area is referred to geographical area that are exposed to disaster.

Both the United Nations and other non-governmental organisations and the government of various countries have made tremendous efforts toward providing solutions to reduce the destructive nature of disasters, which is the primary purpose of disaster risk reduction. Initially, discussion on disaster risk reduction was dominated by emergency preparedness and humanitarian disaster relief materials (Bosher & Dainty, 2011). However, recently attention has been shifted to searching for reliable mitigation plans and measures (Chmutina & Bosher, 2015), that will help to reduce catastrophic disaster impacts in the built environment. UNISDR (2015b), under the umbrella of the United Nations, recognised building code as the vehicle to achieve disaster risk reduction. Many leading international agencies (JICA, 2017; Moullier & Krimgold, 2015; USAID, 2016), have started addressing implementation and compliance of building code as the global priority to accomplish disaster risk reduction.

The use of building code has been viewed as a substantial strategic measure to mitigate the catastrophic nature of disaster by having resilient buildings to earthquake, flood and other related extreme loading conditions (Moullier & Krimgold, 2015). Building code sets the minimum standards required for structural stability, durability, services and facilities, fire safety and other related standards, to protect lives and properties (MBIE, 2014c).

The importance of building code cannot be undermined because the loss of human lives, societal disruption and damage to properties with an emphasis on earthquakes are mostly as a result of total or partial building collapse (Maki & Hayashi, 2000). While some countries established their codes following a catastrophic disaster (IBHS, 2015), other countries establish theirs due to an increase in infrastructural development in anticipation to protect their citizens from any form of a disaster such as an earthquake. However, building code helps to ensure and maintain the integrity of the construction industry in line with structural behaviour during abnormal conditions. Even though building code cannot eliminate risk, but it can reduce risk to a satisfactory level. Petak and Elahi (2000) reported that less destruction experienced in the 1994 Northridge earthquake in Los Angeles was as a result of adherence to building code. The Darfield earthquake in 2010 produced a little impact on the built environment due to the strict implementation of building code in New Zealand (GNS, 2010). On the other hand, the application of building code towards having resilient structures that could resist disaster impacts is lacking in many countries such as Nepal and

Bangladesh (Ahmed et al., 2018). Haiti earthquake in 2010 caused colossal destruction because of non-stringent building code implementation in the country (Lindell, 2010).

The building code has progressed from prescriptive based building to performance-based building code in an attempt to reduce the disaster impacts while improving building resilience. Performance-based building code offer leverages that are still developing, although it also comes with some shortcomings that can be handled. Regardless of its disadvantages, performance-based building code allows for innovative techniques and flexibility that can improve building resilience against earthquake and other related extreme conditions (B. Meacham, 2010a). Building code amendment becomes necessary as disasters occurrence and impacts unfold in various ways. Some of the reasons for building code amendments include reduction of disaster impacts (Ahmed et al., 2018; Lauren Urbanek 2018; Theckethil, 2006; Vaughan & Turner, 2013), the need to catch up with innovative technological solutions (Dixit Amod & Esteban Leon, 2009; Duncan John, 2000; Duncan, 2002b), deficiencies in the building code requirements (Duncan, 2005; James Zuccollo & Mike Hensen, 2012; Maurice Williamson, 2012) and to tightened innovative scope (Mumford, 2010). Building code updates assist in achieving the primary purpose of building code (Nwadike, Wilkinson, & Clifton, 2019a). However, the efficacy of building code amendments require the collaboration of all relevant stakeholders.

The application of the amended building code in design, construction and other related works comes with unique and unintentional challenges that require urgent attention. Addressing these challenges is necessary as it limits the rate of building code compliance, implementation, enforcement, collaboration with relevant stakeholders and cause the unwillingness of the building code regulators and the government to achieve the primary purpose of building code amendment. The post-building code amendment challenges, if not well addressed immediately, can turn little hazards into catastrophic disaster in the built environment with loss of lives, economic resources and well-being. Hence, there is a need to identify and access the impacts of building code amendment. This thesis precisely addresses the impacts of building code amendment in the New Zealand built environment.

1.2. Research problem

The main research problem of this thesis is that the New Zealand performance-based building codes are amended frequently, which has consequences for building code users in terms of their ability to apply and comply with the building code requirements.

New Zealand is geographically located in an active seismic zone that lies along the alpine fault line between the Australian plate and Pacific plate. The country has experienced many earthquakes, with the sequence of 3rd September 2010 Darfield earthquake (Mw = 7.1) and the 21st February 2011 Christchurch earthquake (Mw 6.3) in Canterbury as the most recent devastating disasters in the built environment (Dizhur et al., 2011; Elliott et al., 2012; Ingham & Griffith, 2010). Hence, the question is not if disasters such as an earthquake will occur; instead, the question is if New Zealand buildings are designed and constructed to withstand the impacts of a disaster such as an earthquake without total collapse.

Regardless of the high standard and strict measures of the New Zealand building code, the destructive impact from earthquakes emerge with tragic consequences in the built environment made it evident that many buildings did not sufficiently perform to expectation. In order to improve the building resilience and brace up for future earthquakes, there is a need to access the reasons behind the low building performance. Accordingly, after careful examinations and many insightful lessons learned from the building performance during and after the earthquake occurrence, the Canterbury Earthquakes Royal Commission (CERC, 2011) recommended series of changes to the building code, standards and compliance documents to enhance building resistance for future earthquakes and other related extreme loading conditions. Based on the CERC final report and other sequence contributions, the New Zealand building code has passed through several changes to ensure that buildings in New Zealand can resist earthquake impacts.

However, the use of the amended building code in practice comes with unique challenges to the entire system in terms of implementation, enforcement, compliance, stakeholders and government willingness to achieve the primary purpose of building code. In furtherance to developing a useful construct to ameliorate the unforeseen challenges of building code amendments that will inform the building regulatory policymakers on policy formulation and decision-making process, it is vital to conduct empirical research to address and balance the challenges. The empirical research should include what should be amended, mode of implementation, how to achieve compliance with the changes in the building code, the available resources for enforcement and the various functions of the relevant stakeholders in the building regulatory system as a measure in disaster risk reduction. Implementing the empirical findings will stimulate building resilience in the built environment and compliance with the building code. Based on the above, this dissertation shows particular attention to the impacts of building code amendments, balancing of innovative techniques and compliance with the building code requirements to reduce disaster impacts in the New Zealand built environment. The thesis also attempts to provide recommendations that promote building resilience and building code regulations in New Zealand.

1.3. Research rationale

Appraisal of the research background and problem statement indicates the necessity of addressing the impacts of building code amendments in the New Zealand built environment and developing an evidence-based framework for performance-based building code improvement. This dissertation addressed the contextual background and theoretical concepts surrounding the impacts of building code amendments, code compliance, disaster risk reduction and post-disaster reconstruction in New Zealand as follows:

i) The need to conduct an intensive and integrative literature review on New Zealand building code and the international perspective;

ii) The need to assess the building code amendment process and the factors that contribute towards driving the process;

iii) The need for contextual justification of innovative techniques in performance-based building code and how it affects safety measures.

iv) The necessity to conduct empirical research to study the perspectives of building code users on building code amendments in New Zealand;

v) The need to conduct research to identify the benefits of regular building code amendment in New Zealand and the factors that have contributed to it;

vi) The need to conduct an empirical study to assess the unintended consequences of building code amendment in New Zealand and the associated causes that could limit the primary purpose of building code;

vii) The need to conduct an integrative literature review on how effective building code compliance could improve building resilience against extreme loading conditions;

viii) The need to conduct empirical research to identify the challenges facing building code compliance after building code amendment;

ix) The need to develop a framework on how to integrate the diversity of stakeholder's interests to ensure inclusiveness in building code compliance;

x) The need to conduct empirical research on how to encourage the code users to comply with the amended building code;

xi) The need to develop an evidence-based framework established on identified parameters to enhance building code improvement in New Zealand;

xii) The need to validate an evidence-based framework using subject matter experts for building code improvement;

The enlisted research rationale forms the motivation for this dissertation. The research rationale is specifically drawn from the knowledge gaps existing in building code amendments, regulatory system, enforcement, compliance and implementation in New Zealand built environment.

1.4. Research questions and objectives

The primary focus of this thesis is to assess the impacts of building code amendment in the New Zealand built environment. In achieving the primary focus of this study, the following research questions and objectives were selected, as shown in Table 1.1.

Table 1.1: Research questions and objectives.

	Research questions	Research objectives
RQ1	What are building codes and innovative techniques in performance-based building code?	1. To assess the contextual background of building codes.
		2. To explore the impacts of innovative techniques in performance-based building codes.
RQ2	What processes are followed in building code amendments and	3. To explore the process of New Zealand building code amendment.

	how do code users perceive these amendments?	4. To examine the code user opinion in building code amendments.
RQ3	What are the impacts of building code amendments?	5. To examine the benefits of building code amendments.
		6. To explore the unintended consequences of building code amendments.
RQ4	How do building code amendments affect compliance?	7. To investigate the challenges facing building code compliance after amendments.
		8. To identify the effectiveness of building code compliance in improving resilience.
		9. To examine factors that encourage building code compliance.
RQ5	What parameters are required to develop a framework for building code improvement, and how can it be validated?	10. To identify the parameters required for building code improvement.
		11. To validate an evidence-based framework for building code improvement.

1.5. Research question and objectives connectivity

Building code sets the bare minimum standard required for building construction and other related works. In recent decades, building code has transited from the prescriptive-based building code to performance-based building code. The prescriptive-based building code outlines the step-by-step procedures that must be followed strictly to achieve compliance with the building code requirements. This type of building code provides less form of risk as the building code clearly states what to do and how to do it. The prescriptive-based building code is simple to implement, presents clarity to code requirements, easy to verify and are developed according to well-established products and practices (Pat, 2013). Within the context of prescriptive-based building code, the code users are not expected to bring new ideas outside the scope of the building code. The prescriptive-based building code minimises all challenges relating to the application and use of building code in practice. The quest to improve the use of building code paved the way for performance-based building code. The performance-based building code allows the use of innovative solutions and flexibility in design, construction and other related services within the building regulatory system. The performance-based building code only states the expectations of building performance in any extreme conditions (IRC, 2010a; MBIE, 2014b). However, it offers the building code users the responsibility of determining how to achieve this purpose. This kind of building code encourages the use of any method to achieve the purpose of the building code, which offers an opportunity for international groups or countries to share knowledge. Although performance-based building code allows the use of innovative solutions and flexibility in achieving the primary purpose of the building code, it also presents challenges in demonstrating compliance with the building code (Burby & May, 2000; Duncan, 2005; Jones & Vasvani, 2017b; B. J. Meacham, 2010a). Hence, the need to understand the current contextural background of building code, the international perspectives and the impacts of innovative solutions in the use of building code.

Furthermore, the need to reduce disaster impacts in the built environment, meet-up with modern technological innovation, and noticeable deficiencies in the building code, standards and other related compliance document pushed for building code amendment (Ahmed et al., 2018; Dixit & Esteban, 2009; Duncan, 2005; Mumford, 2010). The Ministry of Business, Innovation and Employment (MBIE) amends the New Zealand Building Code (NZBC) and the associated documents consistently to ensure easier compliance with the building code requirement (MBIE, 2018b). However, the application and use of amended building code, standards and other related compliance documents in design, construction and other services have presented some unintentional challenges that need urgent attention (APN, 2017a; Brian Easton, 2012; Burby & May, 2000; Burby & May, 1999; Burby, May, & Paterson, 1998; Duncan, 2005; Nikki, 2014; Nwadike & Wilkinson, 2020e; Thompson, 1947).

Within the above context, there is a need to understand the process of NZBC amendment, check code users perspectives, benefits and consequences of building code amendment. Achieving building code compliance considering the regular amendments and the use of innovative solutions requires exploring the challenges confronting compliance after building code amendment and identifying effective ways of improving disaster resilience through compliance. Also, creating an enabling environment requires investigating factors that could encourage building code compliance in New Zealand. Accordingly, in ensuring that the primary purpose of building code is maximumly achieved, the need to identify parameters, develop and validate a framework for building code improvement becomes essential.

1.6. Overview of research methodology

This is a PhD thesis with publication style presented according to Massey University guidelines. This PhD thesis with publication style consists of a series of journal and conference papers either published, submitted for publication in an international journal, accepted for publication or under review.

1.6.1. Philosophical underpinnings

Research begins by considering the philosophical underpinnings surrounding the study background, by understanding the focus of the study, aims and objectives of the research and the research design (Cresswell, 2014; Jackson, 2013). As a starting point in understanding and developing a research, (Crotty, 1998; Jackson, 2013) suggested addressing the following questions: (i) what existing theory surrounds the research (ii) what methods are proposed (iii) what methodology rules and guides the choice of method (iv) what is the theoretical rationale behind the methodology (v) what is the ontology and epistemology underpinning of the research. Accordingly, using verified and established methodology provides a useful insight into the advantages and disadvantages of various existing research methodologies and the corresponding methods (Wilson, 2017). Selecting a suitable methodology for any given research depends on the positionality of those undertaking the research and the assumption of the research philosophical underpinnings regarding ontology, epistemology, beliefs and values (Cresswell, 2014; Sikes, 2004).

Ontology

Ontology relates to the philosophical study underpinning the nature of reality which is the initial point of every research (Ansari, Panhwar, & Mahesar, 2016; Grix, 2018). The study of ontology helps to understand what exists independently of human perceptions (Greener, 2011). The researcher's knowledge of the philosophical ontology sharps the methodological decision-making to determine whether a qualitative, quantitative or mixed research method is necessary and fit to achieve any chosen research objective (Jackson, 2013). The ontology study is divided into two categories: (i) materialism and (ii) idealism. The study of ontological materialism deals with the belief that reality exists irrespective of the researcher's perspective while providing an opportunity of sharing individual values and beliefs within a common social norm (Bryman, 2008). The study of ontological idealism presents the concept that reality exists in the mind of individual perception and allows for social construct and human interaction between individuals (Bryman, 2008).

Epistemology

Epistemology is defined as the study of knowledge on which something or knowledge is valid, acceptable and embedded in theoretical and methodological perspectives (Crotty, 1998; Oliver, 2010). Choice of methodology regarding the purpose and goal of any research is centred on the epistemological stance underpinning the research (Ormston, Spencer, Barnard, & Snape, 2014). Epistemological philosophy requires assessing the relationship between the potential researcher and the intended given study, and this is divided into positivism and interpretivism (Bryman, 2008; Hammond & Wellington, 2013). Positivism believes that only a scientific approach that is observed and measured can be used as valid knowledge where a large number of participants are used to collect data based on quantitative research method (Brown, 2017; Gray, 2014; Maclntosh & O'Gorman, 2015). Interpretivism strives to answer the positivism objectives where the reality and knowledge of a given study are influenced by the researchers and not the objectives within that environment, which could be subject to bias, and the research cannot be generalised (Gray, 2014; Maclntosh & O'Gorman, 2015). Table 1.2 shows the detailed comparison between positivism and interpretivism in epistemological perspective.

Table 1.2: Comparison between positivism and interpretivism an epistemological perspective

Positivism	Interpretivism
Involves natural science	Involves human interaction
Identifies regularities and 'constant conjunctions'	Constructs meaningful interpretations based on participants opinion

Knowledge is produced based on observation	Knowledge is formed by exploring and understanding the social world of the people being studied.
Inductive reasoning is applied after data collection	The research process is mainly inductive
Reality is not affected by the research process	Reality is affected by the research process
The methods employed in natural sciences research are appropriate for studying the social world	The methods employed in the natural sciences are not appropriate for studying the social world
Reality can be known accurately	Social reality cannot be captured or accurately represented because they are different

Source: (Ormston, Spencer, Barnard & Snape, 2014)

Methodology

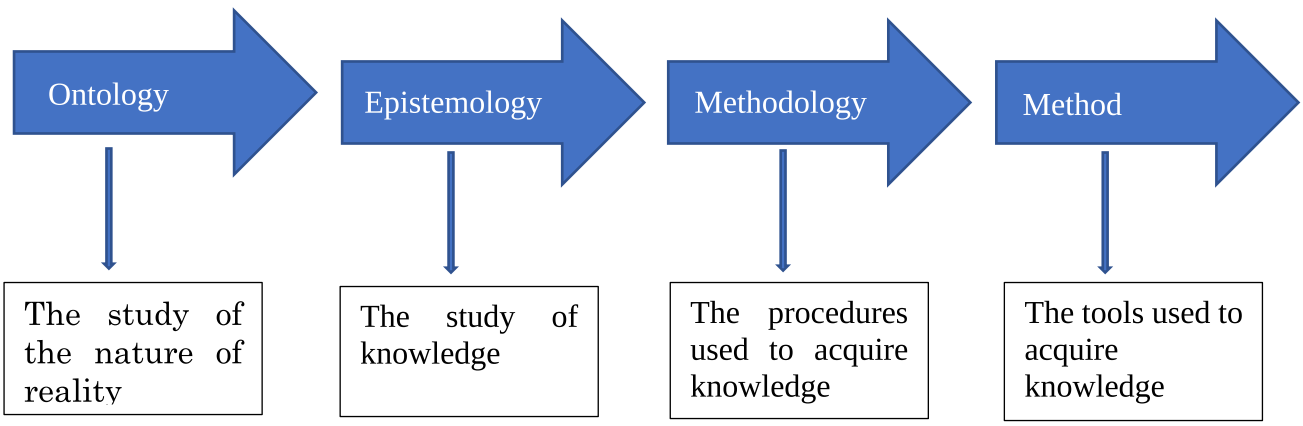
The methodology is an overall procedure of how a researcher designs a study to examine the theoretical underpinnings of a given research problem by identifying, selecting, processing, and analysing pieces of information for data collection about a given topic (Healy & Perry, 2000a; Sileyew, 2019; Wilkinson, 2002). The research methodology helps answer how the research questions are formulated, data collected and analysed (Wilkinson, 2002). According to Buchanan and Bryman (2009), some factors need to be considered before selecting a research methodology that would be appropriate to examine any phenomenon such as: (i) research questions and objectives; (ii) epistemological stance; (iii) the norm in the existing practice; (iv) ethical concerns; and (v) the availability of resources. Ontology plays a significant role in the interrelationship between epistemology and methodology (Scotland, 2012; UKEssays, 2018), where ontology informs the epistemology assumptions that translate to form the basis for a methodology (Mack, 2010).

Method

Research method provides the technique used to acquire knowledge through data collection, data analysis and interpretation to answer research questions (Jackson, 2013). The rationale behind selecting any research method is dependent on the philosophical background underpinning any given research topic. Accordingly, Berry and Kincheloe (2004b) advised using an appropriate research method in answering research questions. This is because a suitable research method provides an accurate and true representation of research findings while ensuring the quality of the research outcome is not compromised (Wilson, 2017).

Relationship between ontology, epistemology and methodology in research

There exist a closed relationship between ontology, epistemology and methodology, and understanding these relationship helps to achieve more relevant research findings (Hammond & Wellington, 2012; Rohrmann, 1998). The relationship between the tripod stance underpinnings any research is directional in a logical sequence that is inextricably linked where ontology precedes epistemology while epistemology precedes the methodology and then to the research method (Grix, 2018; Hay, 2007), as presented in Figure 1.1.



Source: Hay 2007 and Grix, 2018

Figure 1.1: Relationship between ontology, epistemology, and methodology

To understand the impacts of New Zealand building code amendments, the study employs the philosophy of the ontological and epistemological stance to demonstrate that there is a need for social reality relating to the significance of the study in the New Zealand construction industry and the building regulatory system. The study used the perspectives and contributions from the relevant stakeholders that either use or regulate the building code to examine if the reality of the study can be observed, measured and knowledged in New Zealand.

1.6.2. Research paradigm

A research paradigm is the understanding of the belief and assumptions that exist between ontology, epistemology, methodology and method concerns (Johannesson & Perjons, 2014). The word paradigm is a belief system used to explore the theoretical framework of conducting research (Rehman & Alharthi, 2016). The framework helps to understand reality, how to identify a problem and carry out a research investigation. The research paradigm investigates the philosophical concepts of positivism, interpretivism and the associated theoretical concerns while explaining the logic and criteria of research (Rehman & Alharthi, 2016; Samasoni, 2017). Considering the scientific viewpoint, human beings are assumed to follow a set of behavioural characteristics; however, this is not true in reality (Wing, Raftery, & Walker, 1998), particularly in the aspect of exploring the impacts of amending the building code where all the stakeholders have a diverse interest. Also, where the building code users are under pressure to catch up with the series of amendments and could be unmotivated towards complying with the new building code requirements. These situations occur as the New Zealand building code undergoes and still going through changes to improve the building performance and simplify the compliance procedures.

Examing the impacts of regular building code amendments and how to improve the New Zealand building code justifies the necessity of combining the positivism and interpretivism research paradigms of epistemological underpinnings for this thesis. The combination of this research paradigm helps to provide a better understanding of the given study. Accordingly, both positivism and interpretivism have strengths and weakness that need to be considered while understanding any research (Easterby-Smith, Thorpe, Jackson, & Jaspersen, 2018; Ormston et al., 2014). The strength and weakness of the two research paradigms are well discussed in Table 1.3.

Table 1.3: Strengths and weaknesses of epistemological research paradigm

Research paradigm	Positivism (Quantitative)	Interpretivism (Qualitative)
Strengths	• Can provide wide coverage • Fast and economical • Provides ease justification of policies • Can provide considerable relevance to end-users whenever statistics are used in large samples • Results can easily be generalised	• More natural data collection method techniques • Have the tendency to adapt to new ideas • Can understand human's perspectives • Can lead to theory generation
Weakness	• Inflexible data collection methods	• Difficult in data collection with more resources

	• Ineffective in understanding processes • Not good in the generation of theories • The focus may be very narrow because it may be hard to implement social experiments	• May be difficult for data analysis and interpretation • Can be difficult to control the pace and endpoints of the research process • Can lead to low result credibility • Can be difficult to generalise results

Source: (Easterby-Smith et al., 2012)

1.6.3. Mixed methods research design

To achieve the purpose of the research questions and objectives in this study, the thesis used a sequential mixed methods research design approach. The mixed-method research combines qualitative and quantitative approaches to provide robust findings to answer the selected research questions and objectives (Heli Aramo-Immonen, 2013). The two-phased research method takes advantage of their strengths to complement each other's weakness to a comprehensive understanding of the thesis topic (O'Cathain, Murphy, & Nicholl, 2007; Schoonenboom & Johnson, 2017; Wisdom & Creswell, 2013). Also, the mixed-method research in this study provides reliable and facts validated findings, hence, enhancing the methods of data collection used in this dissertation. The research questions and objectives in this thesis are achieved through integrative literature review, questionnaires survey, document analysis, electronic and face-to-face interview, conferences, posters, symposiums and seminars. In the first stage of the research method, the thesis adopted qualitative research to provide instruments for data collection to achieve research objectives one, two, three, partly five and eight. The quantitative approach forms the second stage of the research method to achieve its purpose by answering the research objectives four, part of five, six, seven, nine, ten, and eleven.

This section provides a comprehensive approach and techniques used in identifying, selecting, processing research problem, data collection techniques and the various strategies for data analysis (Healy & Perry, 2000b; Leedy & Ormrod, 2005; Wilkinson, 2002). A mixed-method research approach was used in this research to satisfy the research objectives of this study. The mixed-method research comprises qualitative and quantitative research method.

1.6.4. Justification for mixed-method approach

The primary reason for using a mixed-method style in this study is because data used for this study were collected from different sources, and it provides better philosophical assumptions that combine a qualitative and quantitative approach to enhance the study output (Creswell & Clark, 2017; Ivankova, 2014; Yin, 2006). The mixed-method research approach uses the potential strengths and weakness of both the quantitative and qualitative method of data collection to provide a deeper insightful explanation of a phenomenon (Greene, Caracelli, & Graham, 1989; Lewis-Beck, Bryman, & Liao, 2003; Östlund, Kidd, Wengström, & Rowa-Dewar, 2011). The nature of the research problems in this thesis is complex, contextually characterised, socially constructed and contains psychological features which align with the existing mixed-method approach (Douglas, 2006; Holladay & Coombs, 1993; Santos et al., 2017; Wilkinson & Remøy, 2018). This thesis research questions and objectives achieved a research balance by addressing the phenomenon of 'why', 'how' and 'what' questions, which provides a rationale for using a mixed-method approach (Creswell & Creswell, 2017; Yin, 2018). Also, considering the exploratory nature of the research questions, the complexity of the research problems and the quest to provide comprehensive and reliable result findings (O'Cathain et al., 2007), the use of a mixed-method research approach becomes inevitable. The qualitative phase in this thesis comprises of integrative literature review, narrative literature review, document analysis and subject matter experts interview as an instrument for data collection. The qualitative research method addressed RO1, RO2, RO3, RO8, RO10 and RO11. While the quantitative phase consist of a closed-ended questionnaire to achieve research question RO4, RO5, RO6, and RO9. The interrelationship between all the research questions, research objectives and research methods are summarised in Figure 1:2.

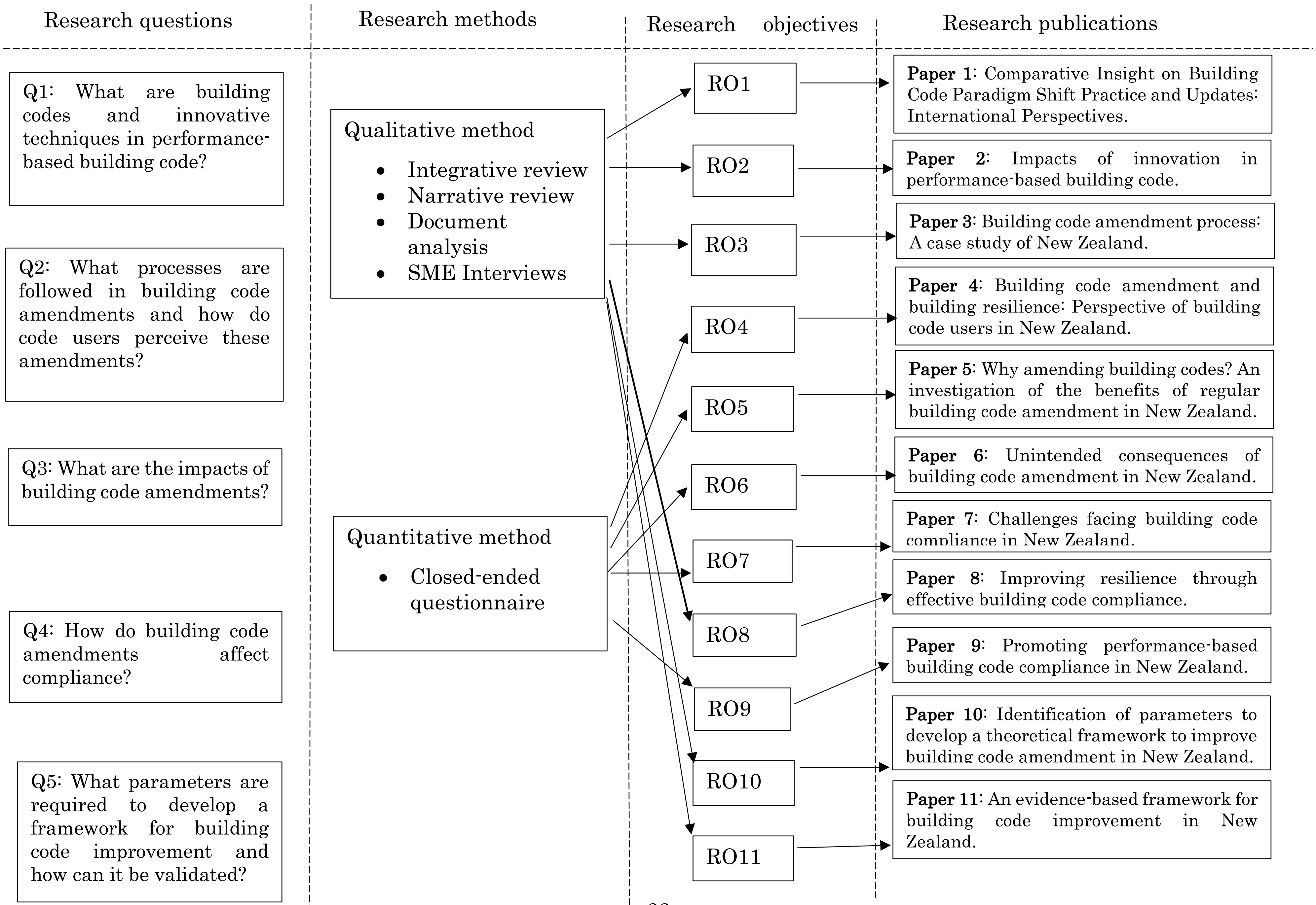


Figure 1.2: Inter-relationships between research methods, questions and objectives.

1.6.5. Data collection method

This thesis used five different data collection methods to answer all the research questions and objectives, as demonstrated in Figure 1:1. The use of multiple source data collection techniques is essential to ensure data reliability, strengthen the credibility of result findings and provide a meaningful interpretation of data in data analysis (Flick, 2013; Merriam, 1998; Shanks & Bekmamedova, 2018). These data collection techniques were selected to Match the practical research questions in this thesis (Kazdin, 2016). All the data collection methods are discussed as follows:

1.6.6. Document analysis

Document analysis is a type of qualitative research method that requires reviewing, evaluating and interpreting trends in existing documents by researchers to give insightful voice within an assessed document (Bowen, 2009; Frey, 2018; Smulowitz, 2017). Interpretation of data in document analysis draws out meaningful information and gives the understanding to develop empirical knowledge based on the reviewed document (Corbin & Strauss, 2008; Rapley, 2007; Wuetherick, 2010).

There are three primary sources of information for document analysis (Bowen Glenn, 2009; O'leary, 2017), namely: (i) public records where official records of an organisation may be reviewed such as annual reports, strategic plans and mission statement; (ii) personal documents where an individual account of events, experience may be examined such as blogs, Facebook posts, newspapers and journals; (iii) the use of physical evidence such as training materials, posters and flyers. Also, document analysis provides background information within a specified context, monitoring growth or decline trends and compliments findings from an existing source of information (Angrosino & Mays de Pérez, 2000; Bowen Glenn, 2009).

The document analysis technique is cost-efficient, less time consuming and reliable while providing an effective source of data collection that is practically manageable (Bowen Glenn, 2009; Caulley, 1983; Wesley, 2010). However, efficient research investigative skills are necessary before using document analysis as the documents under review may not provide all the required information for any given research agenda (Bowen Glenn, 2009; Owen, 2014). The noticeable concerns could be as a result of inconsistency, inaccessibility of data, incomplete or inaccuracy of the documents under investigation, which may lead to bias of the document source (Bowen Glenn, 2009; Cohen, Manion, & Morrison, 2013; O'leary, 2017). Furthermore, careful examination to ensure that the source of data is legitimate and can specifically serve the proposed research purpose is crucial in document analysis (Atkinson & Coffey, 2004).

Accordingly, document analysis was chosen as a method of data collection to address partly RO5 considering its outlined advantages. Historical data on the New Zealand building code amendment from 1993 to 2019 were extracted from the MBIE website (MBIE, 2016j). The extracted documents were carefully analysed to provide an elicit meaning and interpretative construct on the collected data. The data extracted from the MBIE website includes building code amendment counts and the interval of new documents added to the New Zealand building code.

1.6.7. Subject matter experts

A subject matter expert (SME) is an individual who has sufficient skills, knowledge and experience within a particular field (Hopkins & Unger, 2017; Kelly, 1995). The SME's are employed to provide unique and insightful details on a subject matter under consideration based on their standard qualities such as technical expertise within the area of investigation, recognised competence, availability to contribute, independence and level of confidence to have a genuine understanding of the subject under investigation (Lavin, Dreyfus, Slepski, & Kasper, 2007; Marshall, 1996). The SME's contributions could be centres on years of industrial experience or formal education gained over several years (Lavin et al., 2007).

Accordingly, the SME's were used in this research to validate an evidence-based framework developed to improve the New Zealand building code and to address RO 11 under research question five in this thesis. This method of data collection is known to validate frameworks as it seeks to acquire evidence to measure the construct of the subject matter under consideration, and it evaluates the framework validity (Angell, 2017; Clark & Catts, 2007). The use of SME's is a reasonable and cost-effective means of gathering sufficient data for qualitative research within a specific timeframe while allowing the emergence of new ideas (Marshall, 1996). Some of the drawbacks of using SME's includes (Lavin et al., 2007; Marshall, 1996; Pace & Sheehan, 2002): (i) wrong identification and selection of the SME's could unintentionally influence their contributions; (ii) could have hidden agendas regarding the subject matter; (iii) could lead to inadequate response as a result of misconception and lack of clear guidelines on what is expected from the SME's. Before conducting the interview, a pilot study was carried out with the relevant stakeholders that meet the criteria used in selecting the subject matter experts. A pilot study helps test the data collection instrument and identify any potential problem or deficiency in the research instruments before conducting the full study (Hassan, Schattner, & Mazza, 2006). All the corrections and recommendations given in the pilot study were effectively implemented in the interview instruction before conducting the full study.

Nine electronic interviews were conducted with relevant stakeholders to validate a developed framework by exploring their individual opinions, respectively, in improving building code practice in New Zealand. With this study context, the electronic interview is the use of electronic communication facilities to communicate with participants in a video or audio format. The interview with the SME was conducted during the COVID-19 pandemic, hence the use of the electronic interview method to maintain appropriate physical distance. The quality of the electronic interview entirely depends on the technology device and internet connection between interviewer and interviewees (Deakin & Wakefield, 2014). Each interview lasted for approximately 45 to 75 minutes. According to Creswell and Poth (2018), the number of interview participants varies between 5 and 30 participants based on these two main reasons, (i) their advancement in knowledge of the research problem under investigation and (ii) the semantic saturation point of the interview emerging themes. Accordingly, Umar and Egbu (2018) opined that six interview participants are adequate for qualitative study provided the participants gives useful facts in the subject area. The SME was selected as the adequate data collection method as it provides unrestricted opportunities to the participants to make contributions based on their experience. The subject matter experts were selected using purposeful sampling techniques, as it allows the selection of individuals with vast knowledge on the subject matter to offer meaningful and insightful details (Babbie, 2013; J. A. Maxwell, 2013; Neuman, 2014). All the SME's are in top positions in their various companies and organisations, actively using the building code. The selected SME's are regarded as the most suitable individuals to contribute toward improving the building code. One of the primary criteria used in selecting the SME's were that each of them must have practised at least ten years with the New Zealand building code in New Zealand and must have actively participated in the MBIE building code amendment process. The interview participants are characterised by both the building code users and the regulatory authorities, which provides equilibrium for a better validation of an evidence-based framework. Also, the willingness of the intended participants and their confidence level in responding to interview questions were fully considered (Marshall, 1996). The SME's were approached individually using their email address, and upon their acceptance, a convenient date and time are scheduled.

1.6.8. Narrative literature review

A narrative literature review is a method of data collection that critically evaluate existing research related to the topic of interest to provide a comprehensive overview and establish a hypothetical context on a research topic under consideration (Baker, 2016; Byrne, 2016; Green, Johnson, & Adams, 2006; Jahan, Naveed, Zeshan, & Tahir, 2016; Juntunen & Lehenkari, 2019). This data collection technique draws its advantage in summarising previous literature to give a broad conclusion on a topic of interest under investigation (Baker, 2016; Baumeister & Leary, 1997). The narrative literature review, also known as non-systematic review, has no pre-defined standards or guidelines; however, its quality and clarity could be improved by adopting the principles of the systematic review where necessary (Ferrari, 2015). However, well-defined selection criteria of the literature are vital towards improving the quality of the information's conveyed with narrative literature review techniques.

In this thesis, a narrative literature review method was conducted and used to address RO10, which centres on identifying key parameters to develop an evidence-based framework that will improve the New Zealand performance-based building code while maintaining equilibrium on stakeholders diverse interest. The narrative literature review was carried out by identifying relevant information and searching for keywords such as building code, performance-based, compliance, enforcement, implementation, amendment, evidence-based framework and New Zealand in the database such as Google Scholar, Scopus, MBIE website, BRANZ website and web of science. The essential literature review information's relating to the topic under investigation were assessed, identified, screened and used to address RO10.

1.6.9. Integrative literature review

An integrative literature review is a qualitative research tool that reviews, critiques, synthesises and summaries existing literature related to a particular topic in a way that new perspectives, knowledge, understanding and frameworks could be generated on the topic (Russell, 2005; Torraco, 2005; Whittemore & Knafl, 2005). Integrative literature review combines both empirical and theoretical research as a strategy to enhance data collection (Whittemore & Knafl, 2005). However, the complexity of combining two or more research data collection methods could lead to bias, inaccuracy and lack of quality (Beck, 1999; O'Mathúna, 2000). A careful, systematic approach in organising integrative literature review could produce a comprehensive understanding of the topic of interest and reduce any possible drawback in the process (Whittemore & Knafl, 2005). The integrative literature review involves identifying the problem, searching the existing literature, evaluating the data extracted, analysing the data and presenting the data in a unique format that contributes to a new understanding of the topic under consideration (Cooper, 1998; Oxman, 1994; Torraco, 2005; Whittemore & Knafl, 2005).

In this thesis, the integrative literature review was conducted and used to address RO1, RO2, RO3 and RO9. RO1 used integrative literature review was used to address the background of building code with international perspectives and issues necessitating the paradigm shift from prescriptive to performance-based building code. RO2 used an integrative literature review to understand the impacts of innovative techniques in using performance-based building code. Accordingly, RO3 adopted the integrative literature review was used to address the process of amending New Zealand performance-based building code and how the process could be improved. Also, RO9 employed the integrative literature review as a method of data collection was used to investigate the effectiveness of using building code compliance in enhancing disaster resilience in the built environment. The existing literature data were extracted by searching keywords through the educational databases and the organisational websites such as MBIE, BRANZ, Scopus, Google Scholar and Web of Science. The findings from the integrative literature review were used to present a new understanding of the phenomenon surrounding the building code, the regulatory system, and it's potentials in improving disaster resilience in the built environment.

1.6.10. Closed-ended questionnaire

A closed-ended question is a pre-determined quantitative method of data collection that allows the questionnaire participants to select an answer from a defined number of responses option (Colosi, 2006; Lavrakas, 2008). This kind of structured data collection techniques promotes consistency among the questionnaire respondent, as it only allows the selection of answers from a pre-selected option (Colosi, 2006). The closed-ended questionnaire techniques are mostly used where there is a need to quantify data, categorise respondents, large-scale data collection and data analysis (Dillman, Smyth, & Christian, 2014; Gouldthorpe & Israel, 2014). The pre-defined options presented to the questionnaire respondents must be carefully selected to address the primary purpose of the research question; options must not be similar in conceptual meaning and should be easy to understand (Gouldthorpe & Israel, 2014). The data collected through a closed-ended questionnaire survey are normally analysed using different statistical techniques (Wang, Hong, & Hsu, 2006). The closed-ended questions are well-designed, specifically constructed and carefully worded each question in a way that the questionnaire is self-explanatory, including all the specific response options (Boynton & Greenhalgh, 2004; Wang et al., 2006).

In this thesis, the closed-ended questionnaire addressed RO4, RO5, RO6, RO7 and RO9. RO focused on investigating the perspectives of building code users towards building code amendments in New Zealand. RO5 explored the benefits of regular performance-based building code amendments in New Zealand and the associated reasons for frequent changes. Accordingly, RO6 examined the unintended consequences surrounding regular building code amendment and how it could be minimised for improved building regulatory practice in New Zealand. Similarly, RO7 considered the challenges facing building compliance and how compliance could be enhanced among the code users. Also, RO9 centred on examing the usefulness of encouraging compliance with the building code following regular code amendments.

The rationale behind the use of the questionnaire technique is because it is a cost-effective approach to gather a large amount of data, and the obtained data can be quantified (Bird, 2009; Bulmer, 2004; Krause, 2002; McGuirk & O'Neill, 2016). The questionnaire was administered to participants to obtain their opinions regarding the New Zealand performance-based building code amendments, standards and the associated compliance document amendments. The questionnaire consists of the participant's profile information and other sub-sections. The closed-ended questionnaire was constructed to give clarity for easy participation. A pilot study was conducted with relevant stakeholders within the building code regulatory field before the questionnaire survey was distributed to the potential respondents. The pilot study tests the questionnaire instrument and identifies any issue associated with the data collection instrument in preparation for the full study (Hassan et al., 2006). Based on the pilot study outcome, completing the questionnaire survey takes approximately 45 minutes.

A purposeful sampling technique was adopted in the selection of participants in this study based on their knowledge regarding the New Zealand building code. This method allows participants that have vest knowledge on the research focus to be selected (J. A. Maxwell, 2013). The participants were chosen across New Zealand comprising of structural engineers (50%), geotechnical engineers (9.5), architects 1.7%), building services consulting engineers (1.7), licensed building practitioners (6.0%), project managers (12.9%), building contractors (3.4%), local authorities (7.8%), and researchers (6.9%). The closed-ended questionnaires were distributed in person and through online surveys.

1.6.7.1. Data analysis

A total of 250 questionnaires were distributed physically to the selected participants. 33.2% of the administered questionnaire was completed and returned to the researcher. According to Onwuegbuzie and Collins (2007), a return rate above 82 participants is acceptable for correlation analysis. The Qualtrics survey software was also used for the online survey, which generated 33 responses. The online survey was employed to bypass some limitations of distribution in person (Watt, Simpson, McKillop, & Nunn, 2002). Both the outcome of the physically distributed questionnaire and the online platform were combined for the analysis in this study. In total, 121 questionnaires were returned, and only 116 completed questionnaire was used for the analysis in this study. All completed questionnaires were analyzed using the IBM Statistical Package for the Social Sciences (SPSS) software.

1.6.7.2. Questionnaire analysis

The IBM Statistical Package for the Social Sciences (SPSS) software was used to analyse the responses of the questionnaire survey participants. The participant's response was collected and entered into the SPSS software manually in a number-coded format for easy analysis and elimination of any possible oversight error. A spreadsheet of the participant's responses was tabulated in the excel sheet. Each questionnaire was assigned to a heading. This makes it possible to capture the opinion of each participant correctly. The Friedman test (Friedman, 1937) was used to measure the significant differences between each questionnaire item and their varied impacts in measuring the benefits of building code amendment in the New Zealand context. Furthermore, Cronbach's alpha (Tavakol & Dennick, 2011) reliability tool was employed to check the internal consistency of each completed questionnaire item in SPSS software.

1.6.7.3. Friedman test analysis

For this study, a non-parametric statistical test (Friedman test) was used to assess the significance and benefits of building code amendments in post-disaster reconstruction in New Zealand. The test tool was used as the benefits of building code amendment was repeatedly measured across various identified factors. The Friedman test was adopted to evaluate the advantages of the study focus by ranking all the factors according to each participant's view. In the analysis, different factors of measurement were placed on the columns, while the individual participant's opinion is contained in the row format. The null hypothesis was set to capture the main objectives of each of the research objectives addressed using a closed-ended questionnaire (RO4, RO5, RO6, RO7, and RO9). for this study is that there is no significant difference in each identified questionnaire item under the various categories of the benefits of building code amendment. Furthermore, if the significant value *(p)* is < 0.05, the null hypothesis is rejected based on the decision rule.

1.6.7.4. Questionnaire survey reliability check

The reliability test was employed to check the extent to which the study assessment tool measures the consistency of the obtained results. The inter-rater reliability test helps to interpret the various view of the participants in the study. The Cronbach's alpha test (Tavakol & Dennick, 2011) was used in this study to evaluate the internal consistency and reliability of the five Likert scale questions used to assess the impacts of building code amendment in post-disaster reconstruction in New Zealand.

To achieve the purpose of the reliability check in this study, the Cronbach's alpha coefficient was established as follows:

$$\alpha = \frac{N.\overline{C}}{\overline{V} + (N-1).\overline{C}} \tag{1}$$

Where N is the number of questions used in the questionnaire, $\bar{c}$ is the average covariance between the questions and $\bar{v}$ is the average variance.

1.7. Ethical considerations

This thesis was assessed as low-risk research under the University of Auckland Human Ethics Committee. Upon the ethical approval of the committee, the research topic was assigned to an ethics code compliance number **021894** in 2018 for a period of six years interval. However, the researcher transferred to Massey University to complete the research program in 2019 and the ethical approval was fully accepted to be used in the new University. The research reduced the possibility of any unintentional individual or group ethical misunderstanding of the research objectives by administering the participant information sheet (PIS) and consent form (CF) to the participants to fill out before allowing them to participate in the survey. The PIS and CF inform and educates the anticipated participants on each individual or group rights and what the research entails. The participants were given the opportunity to sign the confidentiality agreement forms contained in the PIS voluntarily. The data collection process commenced on the acceptance of each participant from 15th of February to 15th May 2019. All collected data are stored under the premises and control of the University of Auckland, which can only be accessed by the supervisors and the researcher within the stipulated time frame.

1.8. Research scope

This thesis focuses on the impacts of building code amendment as a measure to reduce disaster risks in New Zealand built environment. The research scope covers the research domain of investigation, geographical coverage, and unit of analysis and observation.

1.8.1. Geographical coverage

New Zealand building code is amended at the national level with contributions from various local council authorities and other relevant stakeholders, including individuals. The Ministry of Business, Innovation and Employment (MBIE) is saddled with the responsibility of amending and maintaining the building code. Hence, this research covers all parts of New Zealand's built environment.

1.8.2. Domain of investigation

This research considered the impacts of building code amendments in the New Zealand built environment, including developing code amendment process, its benefits, unintended consequences, code users perspectives, compliance with code changes, its impacts in post-disaster reconstruction and its capacity to reduce disaster impacts.

1.8.3. Unit of analysis and observation

This thesis is primarily conducted within the identified stakeholders involved in the use of any aspect of the building code, including those affected directly or indirectly by the activities of the building regulatory system. For more clarity, the key relevant stakeholders include the building code regulators, local authorities, the construction industry (structural engineers, licenced building practitioners, consulting engineers, building contractors, architects, geotechnical engineers, project managers, building professionals, and quantity surveyors), the research institutions, and the government. The thesis adopted a mixed research method (interviews, closed-ended questionnaires, document analysis, and field surveys) to achieve the research questions and objectives selected in this study. The mixed research method is necessary as it gives opportunities to reach wider communities to contribute to the research topic. Hence, the relevant stakeholders and the selected mixed research approach forms the unit of analysis and observations in this study.

1.9. Thesis outline

This doctoral dissertation consists of a combined twelve series of conferences and journal papers, excluding academic posters that have either been submitted, accepted or published in international conferences and journal proceedings at the time of writing this thesis. Each paper in this thesis is structured in a format that forms a chapter. In this dissertation, each research objectives are represented with a paper, while each research questions are answered with two research objectives, except in research question four, where three research objectives were used. Furthermore, the title of each paper forms the headline for each of the chapters. This dissertation followed the thesis by publication guidelines of Massey University. This thesis provided a factual assessment of the necessity of building code amendments and compliance to reduce future disaster impacts with detailed recommendations to improve the unintended consequences that come with making changes to the building code. An argument is built on the need to balance the innovative techniques in performance-based building code with safety precautions.

The organisation of this dissertation is outlined as follows:

Chapter 1 establishes the research background and defined the problem statement with identified research questions and objectives. The chapter provides an overview of research methodology, research rationale, ethical research considerations, research scope and the significance of the study in a systematic format.

Chapter 2 introduces the contextual background of building code practice in New Zealand with related international perspectives. It provided a comparative understanding of paradigm shift practice from prescriptive based to performance based-building code. The factors that necessitated the need for the paradigm shift and the challenges that need to be overcome to explore the full potentials of performance-based building code in reducing future disaster impacts in the built environment.

Chapter 3 explores the benefits and the unintended consequences of innovation techniques in performance-based building code. This study examines how innovation affected safety clause and compliance in the building code.

Chapter 4 studies the process and timelines of building code amendment in New Zealand, various measures to improve the amendment process, address non-compliance and encourage contributions from all relevant stakeholders with diverse interest. Factors that drivers building code amendment were fully discussed to promote the importance of changes to code regulations and enhance resilience to New Zealand built environment. The chapter stressed that building code amendments do not reduce the impact of disasters, but strict enforcement, implementation and compliance with the changes can reduce the disaster impacts.

Chapter 5 discusses the necessity of building code user's opinions in the building code amendment process. The assessment evaluated how the code user's view could improve building code amendment to increase compliance level while highlighting the consequences of neglecting the user's viewpoint. The study investigated the perceptions of building code users on the need for amending existing building act and codes, improving access to revised documents, scheduled amendment intervals, amendment methods, and the significance of making building code, standards and other related materials free of charge to users.

Chapter 6 demonstrates the benefits of regular building code amendments with New Zealand as a case study. The study examined the identified benefits across building resilience in the built environment, training, technical improvement of building requirements, quality of construction materials and methods, organisational factors, compliance and enforcement. The need to provide free or low-cost technical assistance and adequate awareness of code changes were highlighted. Also, an emphasis on the recruitment of professional technical building officials was pointed out. The study provided useful guidelines for building code policy regulators to expand the benefits of building code amendments in New Zealand.

Chapter 7 probes into the unintended consequences of building code amendment, what causes the consequences and how it can be solved to ameliorate its impacts by analysing the amendment process, the performance-based innovative techniques, code users opinions and identifying the key factors that contributed to the rising unforeseen side effects of building code amendment. Providing satisfactory technical guidelines, reducing code complexity, reducing bureaucracy in building code administration, and reducing regulatory deficiency were highlighted as measures that can immensely reduce the negative impacts of building code amendments in New Zealand.

Chapter 8 examines the challenges facing building code compliance in New Zealand. This study was carried out by identifying the contributing factors and evaluating the inadequate compliance features, organisational factors, insufficient technical training and assistance, inadequate enforcement strategies, and inadequacy in proving awareness on changes in building code. The study explored guidelines on minimising the challenges and the implications of neglecting the challenges confronting building code compliance.

Chapter 9 explores in detail the efficacy of improving resilience using building code compliance by developing a compliance framework with incentive features that could propel voluntary compliance among the code users. Identification of voluntary compliance drivers, fostering a mixed-method approach in enforcing compliance and stakeholder's responsibilities in building code, and formulation of capacity building to encourage code compliance was discussed.

Chapter 10 develops a concept that integrates the inclusiveness of stakeholder's diverse interest to encourage building code compliance. The study highlighted the necessity of balancing building code amendment, quality and innovative techniques against safety while forming a guide to the code users to limit all application of innovation within the compliance zone to improve the built environment resilience. The chapter showed that the effectiveness of improving compliance requires creating an enabling environment through the implementation of the compliance concept 6P's that includes; people, process, planning, policy, product, and performance.

Chapter 11 identifies parameters and criteria for evidence-based framework development to improve the building code, its amendment, standards and the associated compliance documents. Also, the chapter explores how each identified parameter contributes to achieving the primary functions of the building code practice in New Zealand.

Chapter 12 Validates an evidence-based framework developed for building code improvement using the subject matter experts research method.

Chapter 13 presents the summary and conclusion of the study, research findings and vital contributions in building code amendment, disaster risk reduction and post-disaster reconstruction. The chapter provided suggestions and opportunities for future research.

2. Comparative insight on building code paradigm shift practice and updates: International perspectives

This chapter was extracted from Conference Publication № 1, Proceedings of the 4th International Conference on Civil, Structural and Transportation Engineering (ICCSTE' 19), Ottawa, Canada – June 11 – 12, 2019. Paper No.: ICCSTE 143, DOI: 10.11159/iccste19.143. This chapter aims to answer the research question RQ1 and research objective RO1.

Abstract

This chapter shows an overview understanding of building codes practice in different countries across the globe. The approach to building code practice and updates differs from country to country, but its primary aim is to provide the minimum requirements to protect life and properties in the built environment. The building code philosophy is to avoid building collapse during and after an earthquake and other related extreme loading conditions. The data approach for this study was from a secondary source using an integrative literature review method. This review aims to examine the paradigm shift in building code practice across different nations to determine which countries are embracing performance-based regulation through efficient building code improvement. The paper lays out performance base approach status, mode of compliance, amendment interval, issues that necessitate updates, implementation, code enforcement and highlight

some challenges that need to be overcome to harness the full potentials of the innovative building code practice. The study provided a better understanding of comparative insights into the various building code in the selected countries and the factors that encouraged the paradigm shift in building code to accommodate technological innovation in the construction industry. The chapter showed that many developed and developing countries are gradually shifting from prescriptive-based code to performance-based building code due to innovation, economic boom on infrastructure and persistent disaster occurrence in the built environment.

2.1. Introduction

Following the consistent occurrence of a disaster and its destructive nature, the building code has been seen as a measure of having a safe built environment. Building code provides the minimum structural safety requirements to protect lives and properties during or after an earthquake and other related extreme loading conditions. Many countries have introduced, enacted, updated and enforced their building code over the years to conform to the current demand to have a safe built environment. The impact of a disaster or the likelihood of its occurrence has threatened the peace of human, especially earthquake, which has the highest number of the death toll. Most of the deaths come as a result of total or partial collapse (Maki & Hayashi, 2000) of the building during the extreme loading.

The most deadly disaster that necessities the introduction of building regulations in many countries is the earthquake. Some of the selected countries established their codes following a catastrophic disaster (IBHS, 2015), while others as a result of an increase in infrastructural development in anticipation to protect their citizens from any form of a disaster like an earthquake or through creative research. However, building standards help to ensure and maintain the integrity of the construction industry in line with structural behaviour during abnormal conditions. Even though building code cannot eliminate risk, but it can reduce risk to a satisfactory level. Ahmed et al. (2018) firmly agree that building code is the vehicle for achieving disaster risk reduction in the built environment.

This chapter presents the conceptual framework addressing the decision of countries moving from prescriptive based building code to performance-based method, method of compliance, amendment intervals, issues necessitating building code updates and enforcement and ways of updating building code. The list of chosen countries and year of first building code establishment respectively are shown in Table 2.1. Reasons for building code or regulation establishment vary from country to country. These reasons range from providing safety to humanity and properties due to experienced disaster or unforeseen disaster in, booming in infrastructural developments, innovation in research and otherwise.

Table 2.1: List of building code establishment and updates of various countries.

	Country	Year of first code introduction	Update Interval	Reason for building code.	Enforcement	Regulatory bodies
1	New Zealand	1842	No specific period but regularly	Earthquake and research innovation	Ministry of Business, Innovation, and Employment [MBIE]	Ministry of Business, Innovation, and Employment [MBIE]
2	Australia	1965	3	Earthquake and research innovation	States and territories	Australian Building

						Codes Board [ABCB]
3	Canada	1941	5	Earthquake and research innovation	Province and territorial governments	Canadian Commission on Building and Fire Codes and the Canadian Code Centre.
4	Japan	1919	Between 3 to 5	Earthquake	Japan municipal government	Japan central government
5	Vietnam	1961	No specific period but regularly	Research innovation and boom in infrastructural development.	Ministry of Construction and Provincial People's Committees	Ministry of Construction
6	UK	1666	No specific period but regularly	Innovative research	UK government, the Welsh government, the Scottish government and the Northern Ireland Executive	Ministry of Housing, Communities & Local Government and Building Regulations Advisory Committee
7	USA	1645	3	Earthquake and research innovation	Federal, States, Counties, and Cities,	No specific body but includes ICC, IAPMO NFPA, ASHRAE.

2.2. History of building code in the selected countries

The first known building code dated back to 1772 BC by King Hammurabi of Babylon. The building code has progressively developed over time, but its aim remains to protect lives and properties in the built environment. Among the countries under consideration, the USA was the first country to introduce building regulation in 1645 before their constitution took effect in 1789 (B. Meacham, 2010b), followed by the UK in 1666 after the great fire of London. The USA has no unified building code, but the International Building Code (IBC) is the most widely used code, administered by the International Code Council (ICC) (Chong, 2013a) and (B. Meacham, 2010b). Japan began research into earthquake resistance structures following the 8.0 magnitude earthquake of Mino-Owari in 1891. Japan lies in an active seismic region in the Asian continent and has experienced several earthquakes of higher magnitude compared to any country around it. First, Japan recognised uniform building code was established in the year 1919, known as the urban building law (Maki & Hayashi, 2000). In 1961, the first Vietnam construction standard was introduced; however, it served till 1990. Vietnamese construction standard was coined from the former Union of Soviet Socialist Republics (USSR) building standards (Nguyen, 2006). New Zealand building regulation started in 1842, known as the Raupo House Ordinance and was later replaced with the Municipal Corporations Act in 1867. The 1931 earthquake pushed for the establishment of building standards in New Zealand in 1935. The 1991 Building Act in New Zealand became the enacted national building standard in the country. The official building code of Australia was enacted in 1988 through the establishment of a committee called

Interstate Standing Committee on Uniform Building Regulation (ISCUBR) drafted the building code from the existing building regulation called the Australian Model Uniform Building Code (AMUBC) in 1965 (NCC, 2015a). In

1914, the first Canadian National Building code was published, although there were existing building regulations guiding the building construction. The Canadian constitution included that building regulation is the full responsibility of each province.

2.3. Issues necessitating building code and enforcement

Building code updates have been a consistent long practice, although some of the amendments are as a result of the after-effect of disasters (Wieczorek, 2018), like earthquake rather than an act of forethought (IBHS, 2015), to reduce the disaster risk. Review and improvement of building code should be a critical and integral part of pre-disaster planning to avoid the loss of lives and properties rather than a post-disaster scheme. The result of building code updates majorly depends on the type of code, location, and approach towards modification, the method of application and enforcement and the readiness of the involved stakeholders in handling the updates post challenges. The dedication and commitment of the stakeholders towards achieving a successful building code update is a crucial issue for consideration.

Building code modification aims to reduce disaster risk in line with building back better principles, which includes integrating disaster risk reduction activities into the existing standards to have buildings that are resilient to earthquakes and other related extreme loading conditions. Reducing the impact of a disaster is one of the primary reason to have a frequent building code amendment; hence, the non-amended building code is a disaster on its own over a period. Updating building code gives the opportunity to make corrections, include omissions, introduce new concepts or methods for smooth implementation, respond to changes from research findings, gained experience, and meet up with the expectation of the society (NCBCS, 2018a).

It is a good practice to modify existing building code, but when the amendment should take place, what should be amended, and how to improve the code becomes a challenging issue that poses a question to answer. Hence, holistic impact analysis is critical because it gives answers to the raised question above. (Vaughan & Turner, 2013) Suggested that codes should be reviewed every three years since it is the average duration for a business cycle. In this study, the selected building codes have undergone a series of revisions at different time intervals. Recently, the USA and Australia building code are updated every three years, respectively, to welcome new creative innovations and add market value. The first Australian building code in 1988 was later modified in 1990, and from 1st of May 2004, the code was set to be updated yearly before its extension to three years cycle interval in 2016 (NCC, 2016). New Zealand, the UK, and Vietnam have no specific time interval for building code updates; however, the amendments are carried out whenever the need arises. In 1924, earthquake-resistant construction regulations were reviewed and updated due to the Great Kanto earthquake in 1923 that caused significant havoc in Japan. Subsequently, Japan building standard Act undergoes several revisions following almost every earthquake incidence (Hasegawa, 2013; Maki & Hayashi, 2000), although (Moullier & Krimgold, 2015) stated that it is updated between 3 to 5 years but not mandatory. The Vietnamese construction standard has passed through numerous amendments, some of which are based on other standards like the American Standards System and British Standard (Nguyen, 2006).

Furthermore, the Ministry of construction Vietnam allows the use of other building codes to practice in the country, but designs made with such codes must seek approval from the construction authorities, and this accounts for the economic growth in the construction industry in Vietnam through the influx of foreign investors. The Canadian building code has been on a regular revision scale every five years from 1960 to date to welcome innovations into the Canadian construction industry. In the UK, the Building Regulations Advisory Committee raised a concern that before a baseline of 5 years will be accepted for updating the UK building code, there should be a clause for flexibility for the necessary amendment (Michael Finn & Alastair Soane, 2007). Notwithstanding, there is no specific interval for updating the UK building code, but it is regularly updated.

Despite that building regulations should be subject to change over time, it is evident that when it is frequently changed without outlined guiding principles that include the periodic intervals and required training in a coordinated manner, it can become complicated for its users regarding implementation, this can result to disaster on its own.

2.4. The paradigm shift in building code

The quest to have a building code that is flexible in implementation and appreciates creative innovations has caused a tremendous paradigm shift from the conventional prescriptive based building code to a performance-based approach.

These have been viewed as a one-step further technique (B. Meacham, 2010b) because it clearly defines the expected performance criteria end-result of how a structure should behave during an earthquake and other related extreme conditions over its lifetime service. A prescriptive based method outlines the step by step procedure on how to build a structure, and when strictly followed, it is deemed fit to demonstrate compliance. One of the main advantages of the Performance-based approach is that it encourages technological innovations from all users, but professional skills are mostly required, while the latter gives the detailed procedures which are accomplished without more professional skills. The prescriptive method is straightforward when all the laydown procedures are clearly stated and strictly followed. Thompson (1947) opined that the cost of construction and failure of new construction material to gain space in the construction market necessitated the improvement in the building code. According to Scott Williams (2016), the performance-based method delivers structures that are more aesthetical at a lower cost. Mumford (2010) noted that performance-based building code outlines the mandatory goals expected of a building rather than enforcing prescriptive based regulations. The Centre for International Economics, Benefits of Building Regulation Reform, Canberra affirmed in 2012 that the use of performance-based regulation had increased the productivity gain of the Australian building and plumbing industry.

Almost all the first published building code of countries started with a prescriptive method, but the gradual popularity of the performance-based method shows that it is an excellent measure to achieve a better safe environment. Especially as Kausel (2010) noted that seismic code does not only protect people, but it also tries to protect the buildings themselves. To encourage building code implementation and compliance to achieve a safe built environment, the performance-based approach gained increased popularity. The Organization for Economic Cooperation and Development (OECD) have attracted member countries to adopt the performance standard to improve their respective economic efficiency through increased building regulation incentives (Takahiko, 2003). UNISDR (2015a) Strongly advocates for building code amendments as a priority measure to achieve a disaster risk reduction environment.

However, it presents some unique challenges in satisfying this approach regarding incurred cost and complex calculations and laboratory test to achieve compliance. Although the performance-based method has been introduced in many countries, in some cases, the method of cross-checking designs still follows the usual conventional method. The prescriptive method is cost-effective (Takahiko, 2003); nevertheless, it does not allow for flexibility in design. Although, Mumford (2010) argued that performance-based regulation reduces regulatory cost. Though the performance-based way may be more beneficial in both flexibility and products design, it is problematic to test or validate the performance of complex structures upfront. Hence, adequate care must be taken to use performance-based criteria in regulations, guidance, and standards, and it is advisable to implement additional prescriptive methods in conditions of complex structures (Denton S & M, 2017).

The United Kingdom championed and pioneered the first published performance-based building code as early as 1985, followed by New Zealand in 1992 building code based on performance, Japan in 1998 but was enforced in 2000 with stricter laws and Australia in 1998.

It was a difficult task for the USA building code to be converted to performance-based regulation because of non-unified code, and most importantly, the United States codes are not promulgated by the federal government (Meacham, 1997). However, the performance-based code was adopted in 2002 as specified by the International Code Council (Foliente, 2002). The USA performance regulation was formulated based on the key features of the United Kingdom, Australia, and New Zealand performance-based codes (Meacham, 1997). New Zealand building code has undergone several modifications that introduced performance-based approach building code in the 1991 Act but were enforced in 1992. The performance-based building regulation in New Zealand was designed in accordance with the Nordic model (Buckett, 2014), which can be compiled through Verification Method, Acceptable Solution, or Alternative Solution. An update in 2012 to the New Zealand performance regulation enhanced more creative opportunities in design and specification by the use of numerical modelling to display compliance through the provision of the Verification Method for fire protection (C/VM2) (Buckett, 2014). The Japanese performance-based building standard only states the objectives, and functional requirements of the performance approach; however, (Foliente, 2002) suggested that it is a quantitative performance code. The Ministry of construction of Vietnam established a Vietnamese building code embedded in the performance-based concept in 1996, this concept outlines the minimum technical guidelines appropriate to accomplish compliance, and it also makes provision for attaining compliance through deem-to-satisfy provisions (Nguyen, 2006). However, the Vietnamese performance-based approach seems to be shallow in providing required criteria's in some areas, thereby leading to difficulties in implementation (Nguyen, 2006). The innovation in the Canadian construction industry in 2005 paved the way for the publication of the first objective-based building code (Bergeron, Desserud, & Haysom, 2004), which allows the use of more performance and less prescriptive based approaches to attain compliance. The code gave a detailed measure to gain compliance without confusion (Meacham Brian, 2010). The Australian building code was fully converted into the performance-based method in 1996 through the establishment of the Australian Building Codes Board (ABCB) in 1994. The building code of Australia consists of objectives, functional statements, performance requirements and building solutions (Beller, Foliente, & Meacham, 2003) that is contemporary, progressive and working well (Scott Williams, 2016). Different years of performance-based building code adoption in various countries are illustrated in Figure 2.1.

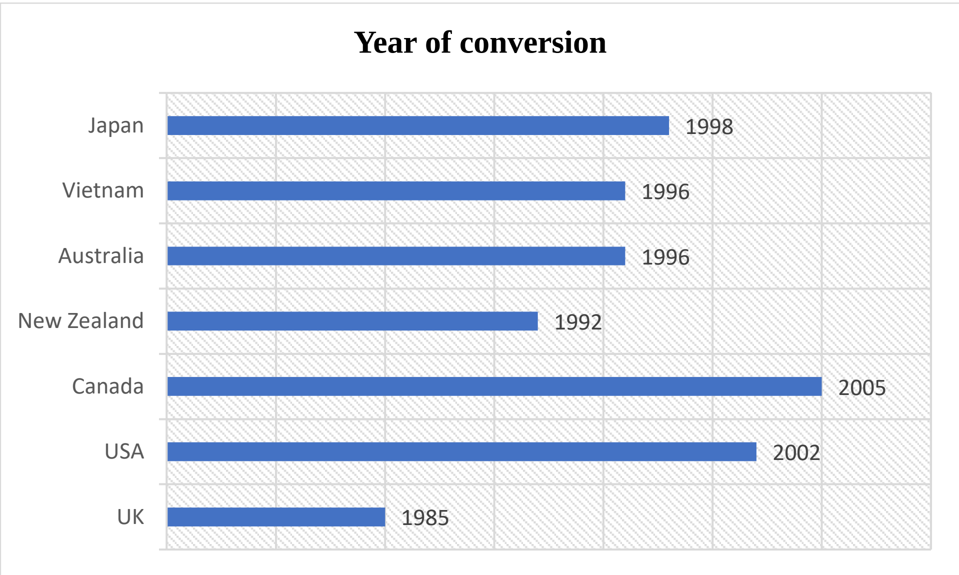


Figure 2.1: Year of adoption of the performance-based building code in various countries.

The international council for research and innovation in building and construction (CIB) and the Inter-jurisdictional Regulatory Collaboration Committee (IRCC) provides an international platform where different countries discuss and share ideas on how to improve their performance-based regulation (B. Meacham, R. Bowen, J. Traw, & A. Moore, 2005). Figure 2 shows the list of various countries and when the adopted and enacted performance-based building code into law.

2.5. Method of compliance with performance-based building code

The introduction of performance-based building code has gained full spread acceptance, and many countries have adopted the technique to grow their respective construction sector. The majority of the countries that changed their codes to performance-based followed the hierarchy defined by the Nordic Committee on building regulation (Meacham, 1997; Regulations, 1976) as shown in figure 2, to achieve compliance. However, the application differs from country to country (Beller, 2001). It was later discovered that more explanatory criteria's and measures are needed to evaluate compliance through a performance-based method (Meacham Brian, 1999). In response to the compliance deficiency in the performance base method, Meacham J. Brain developed and modified the (Regulations, 1976) hierarchy into an eight-tiered performance-based hierarchy in collaboration with the members of the Inter-jurisdictional Regulatory Collaboration Committee (B. J. Meacham, 2010b) and (B. Meacham, 2010b) as shown in Figure 2.

Basically, there are three major ways used to demonstrate compliance to building regulations in line with the performance-based approach followed by many countries like New Zealand, Australia, Japan, the UK, USA etc. Firstly, the verification method allows the use of a testing method (laboratory test), engineering analysis like calculation and experimental measurements (tests-in-situ), which, when adhered are deemed fit to compliance. Secondly, the acceptable solution prescribes specific construction methods like the prescriptive based approach by giving step-by-step processes of how a structure should be built to show compliance, which is normally used in a simple residential building. The final method is the alternative solutions where the leading innovation and uniqueness are embedded in performance-based regulation because it empowers the designers to introduce a new solution (Ministry of Business, 2016). This method uses qualitative or quantitative measures to demonstrate compliance to the building code, like a comparison with the verification method or the acceptable solution, expert evidence, trading literature, etc., to show compliance (MBIE, 2016b). The quantitative measure here means defining the required performance level and can be seen as prescriptive if it contains performance requirements, while qualitative measures are the objectives, functional statements and occasionally performance requirements (Beller, 2001). Concerning compliance, building projects in Australia are manually checked against the building code for certification purpose, which is prone to error and time-consuming (Jeong & Lee, 2009). This problem is complicated by regular amendments of the building codes (Greenwood, Lockley, Malsane, & Matthews, 2010; Tan, Hammad, & Fazio, 2010). Shih, Sher, and Giggins (2013) Recommended the use of a BIM-enabled code checking system to the Australian building compliance process.

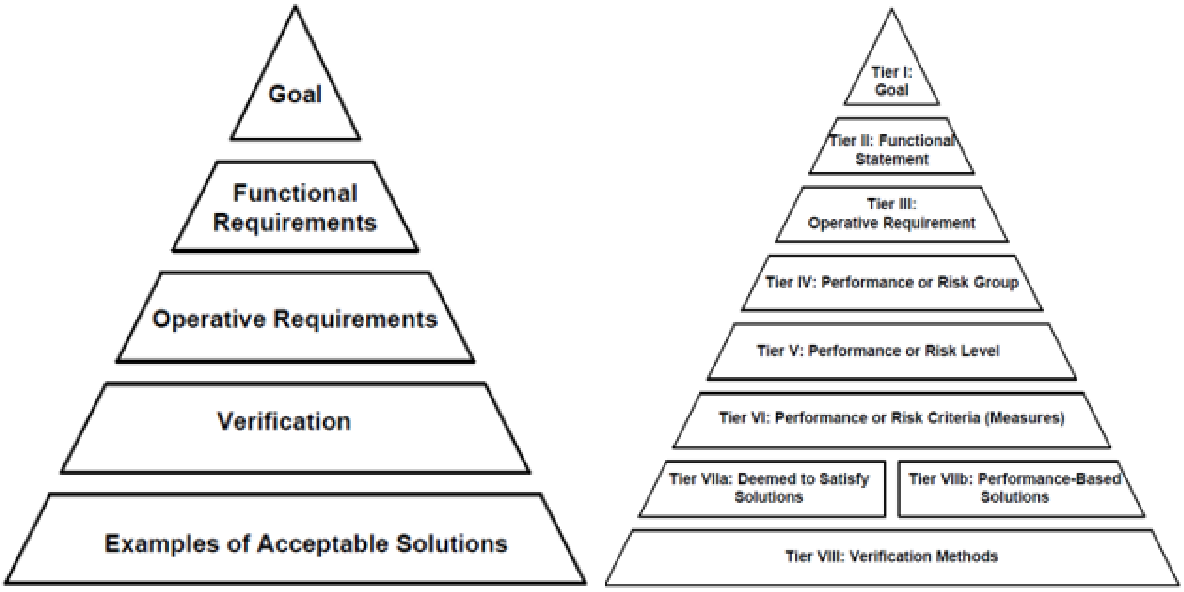


Figure 2.2: NKB hierarchy model (Regulations, 1976) (left) and the eight-tier hierarchy model; (B. Meacham, 2010) (right).

However, in 2016, Australia's National Construction Code (NCC) simplified the compliance structure and changing terminologies by making more clarifications between the compliance level and guidance (Armstrong, Wright, Ashe, & Nielsen, 2017), as shown in Figure 2.3. NCC also changed terminology that leads to the building code pathway to compliance by renaming alternative solution to performance solution (Armstrong et al., 2017).

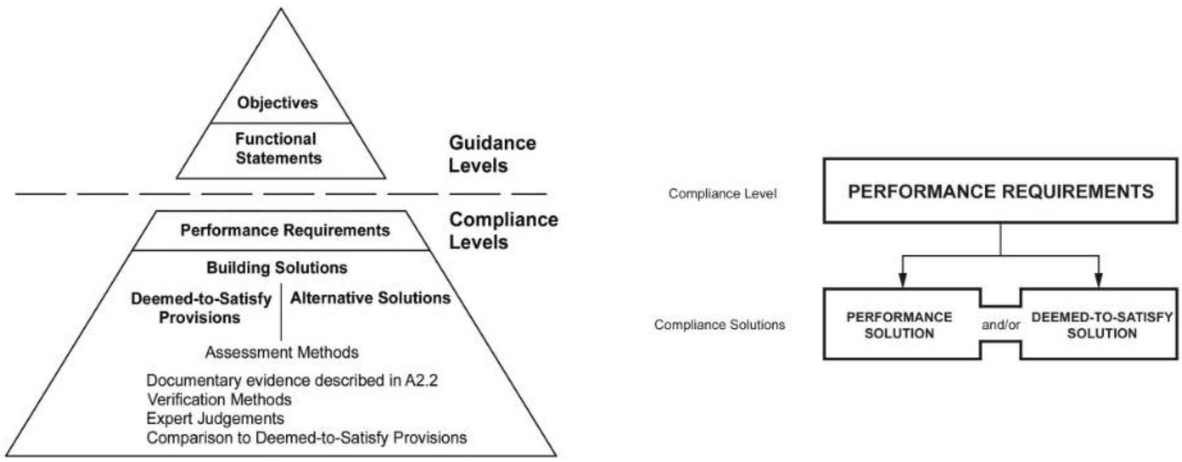


Figure 2.3: NCC changes to compliance structures (2015 left and current 2016 right) (Board, 2015, 2016)

2.6. Conclusion

The history of building code development in various countries showed the efforts to have a safe built environment. Experience gained from disaster and research innovation created the quest to have a building code that is flexible in implementation and appreciates creative changes in the construction industry. These have caused a tremendous paradigm shift from the conventional prescriptive based building code to the performance-based approach. Despite the advantages accorded to performance-based building code, there are still difficulties in demonstrating quantifiable compliance without reliance on prescriptive solutions. The study showed that it is a good practice to establish a building code; however, enacting and enforcing building code without regular updates will amount to a waste of time within a short period. These further revealed that non-amended building code is a disaster on its own. Non-improvement of building code creates gaps that endanger the lives and properties and notifies the primary purpose of building code practice. Review and amendment of building code should be a critical and integral part of pre-disaster planning to prevent loss of lives and properties. Building code modification aims to reduce disaster risk in line with building back better principles, which includes integrating disaster risk reduction activities into the existing standards to have buildings that are resilient to earthquakes and other related extreme loading conditions.

3. Impacts of innovative techniques in performance-based building code

This chapter was developed from Conference Publication № 2, has been published under the New Zealand Society for Earthquake Engineering conference 2020. This chapter aims to answer the research question RQ1 and research objective RO2.

Abstract

The purpose of this study is to assess the benefits and the unintended consequences of innovation in performance-based building code with an emphasis on New Zealand building code. Also, this paper examines how an innovative approach has affected the safety clause in the building code. An integrative literature review approach was used to explore the impacts of innovation in performance-based building code practice. Although the innovative approach in performance-based building code allows for creativity, flexibility in both design and construction, the use of new technological concepts and new construction materials, there remains significant challenges that need technical guidelines and training to overcome. The findings show the difficulties in achieving compliance through the use of innovation while trying to improve building resilience in the built environment. The study concludes that innovation may have unintentionally affected the safety clause in the building code. Hence, the study recommends innovation impact analysis before building code amendment. The study used

secondary data collection. Hence, there is a need to use primary data collection to validate the findings from this study. The study is unique in its approach to explore the impact of innovation in performance-based building code in New Zealand and beyond.

3.1. Introduction

Many countries have moved from prescriptive based to performance building code in search of a robust approach to the minimum the effect of natural hazards in the built environment. The transition driver to performance-based building code is based on innovation and is expected to allow for cheaper products, creative design and construction (Foliente, 2000). The conventional building code describes the step by step procedures of how to achieve building requirements, while the performance-based code only states the building performance during and after a disaster. Furthermore, the conversion is underpinned by the inherent barriers with prescriptive building code relating to the acceptance of new products, construction materials and efficient building system (Martin sexton & barrett, 2005). The application of new technologies and better quality for structural performance and fire safety makes it easier for the paradigm shift to performance-based building code (Duncan, 2005; Haberecht & Bennett, 1999).

The 1991 Building Act enactment came with the conversion of the New Zealand building code to performance-based building, which came into force in 1992. The transition comes with an innovative clause that meets the societal expectation and sustainability of the built environment (John R. Duncan, 2000). Furthermore, the introduction of an innovative approach in performance-based building code created an additional pathway to achieve compliance, although the prescriptive aspect was retained. In essence, performance-based building code only creates an enabling environment where the ideas of innovation could be sustained. Within the context of this study, innovation refers to allowing the building code practitioners to be creative, flexible and use the alternative solutions to achieve compliance.

Even though it can be argued that innovation improved compliance (B. J. Meacham, 2010b), it also created room for debate and placed the building code officials in the spotlight of making decisions on new concepts that are out of 'deemed to satisfy' while considering the liability of such action (John R. Duncan, 2000).

As innovation continues to gain popularity around the globe, Duncan (2005) noted the need for extensive technical training for both the regulators and the regulated to implement the option of innovative ideas embed in performance-based building code. The option of innovation could be redundant or wrongfully utilized without adequate training and supervision.

Presently, no country has a full performance-based building code in practice (Becker, 2008), because the prescriptive procedure is still retained (John R. Duncan, 2000). In New Zealand, the prescriptive based building code is retained as an acceptable solution, which is widely used for building methods and systems (MBIE, 2014a). This could be as a result of the unforeseen challenges surrendering the application of innovation in practice regarding compliance and other related barriers that prevent the full implementation of innovation. Accordingly, John R.

Duncan (2000) pointed out that these barriers made countries blend the performance-based building code with prescriptive building code. With this approach, the innovative hurdles are eliminated while improving on the benefits of innovation (Meacham, Tubbs, Bergeron, & Szigeti, 2003).

This study seeks to assess the benefits and the unintended consequences of an innovative approach used in performance-based building code. The study also examined how innovation unintentionally affected the safety clause in the building code. This study presented the findings from an integrative literature review (Torraco, 2016) perspective that an innovative method in the performance-based building code needs to be developed, certified and supervised by the appropriate entities. Achieving compliance through the use of an innovative method demands that both the regulated and the regulators must have adequate training, especially the building officials that will certify the new concepts.

3.2. Benefits of innovative approach in performance-based building code

The introduction of an innovative approach in the application of building code requirement was welcomed in the building industry. The innovative clause paved the way for performance-based building code, which New Zealand is among the pioneers (Meacham Brian J., 2008). With such acceptance, the innovation method cut across many areas in the building industry, such as building performance, construction materials, design, construction and administration. The paradigm shift to performance-based regulation is a result of the additional opportunities the innovative clause offered to the industry (B. J. Meacham, 2010a). However, R.E. Humpreys (1985) stressed that innovative system would not bring an immediate solution to the challenges faced in the building industry. Hence, innovation should be well understood and developed up to the point that it could be sustainable regarding implementation and demonstrating compliance.

Many are of the opinion that prescriptive regulation makes it difficult to introduce the use of innovative methods in the building industry (Eisenhardt; Foliente, 2000; John R. Duncan, 2000; R.E. Humpreys, 1985), especially regarding flexibility in design and construction aspect (Armstrong et al., 2017; Martin sexton & barrett, 2005; B. J. Meacham, 2010a). John R. Duncan (2000) opined that the introduction of innovation helped to achieve the safety clause stipulated in the building code.

Furthermore, innovative ideas allow the building code users to create solutions that can withstand the impact of natural hazards compared to conventional regulatory practice (Armstrong et al., 2017), as some challenging tasks require a unique approach. Accordingly, this requires the application of building code users ingenuity to attain the needed outcome (John R. Duncan, 2000). Also, Armstrong et al. (2017) noted that innovation allows the code users to explore new areas and develop solutions that could be mainstreamed in practice. Although these newly developed methods may need additional verification process to demonstrate compliance and it is entirely dependent on the approval of the building officers.

Accordingly, innovation in performance-based building code offered varieties of opportunities that can be used to achieve compliance. In the New Zealand context, these compliance pathways are evident in alternative solution and verification method. Further, this compliance pathway solved the problem of the analytical method to some extent (Greenwood, 2007), while some work needs to be done to improve the innovative process (Armstrong et al., 2017). Validating the innovation techniques used in the building sector before acceptability of such method is essential to minimise the impact of unintended consequences of innovation (R.E. Humpreys, 1985). Therefore, this crucial process does not impede the use of innovative ideas in design, construction, new materials, methods and product (Wright, 1983); instead, it ensures that innovative practices that could protect the built environment are reasonably implemented.

Many in the building industry believed that innovation saves cost and promote productivity in the building sector (ABCB, 2016; Armstrong et al., 2017; CIE, 2002; B. J. Meacham, 2010a). The cost could be as a result of providing smart solutions that overcome the barriers set by prescriptive building code. On the contrary, some think that innovation contributed to the rising cost with an increase in design cost, construction and in return increased the housing cost (Eric Baczuk, 2016; Listokin & Hattis, 2005). Moreover, there is always cost attached in verifying innovative solutions to demonstrate compliance, especially in a small market environment such as New Zealand (Dermott McMeel & Kevin Sweet, 2016; Duncan, 2002a). Although, the innovative solutions in performance-based building code promote global trade among member nations that use performance-based regulations (Meacham, 2009; NCC, 2015b).

3.3. Unintended consequences of innovation

The innovative approach embeds in performance-based building code is not without some unforeseen challenges that could hinder the full implementation of innovation in performance-based building code. However, many are in the illusion that the introduction of innovation in the building sector would solve all the existing lapses in the prescriptive regulation (B. J. Meacham, 2010a; Paul Everall, 2003).

Transiting from prescriptive to performance regulation could require additional professional skills, especially when it comes to interpreting and verifying innovative solutions. Conversely, some of the building code users lack the essential knowledge and professional skills needed to implement innovative methods and solutions in practice (Coglianese, Nash, & Olmstead, 2003; Nilson & Olson, 1981; SBCCI, 1992). Hence, building officials are placed under pressure to determine whether innovative solutions are adequate or acceptable (Duncan, 2005). The pressure on both the regulated and regulators to prove that innovative solutions meet the performance specifications could lead to a diverse interpretation of performance criteria (Dermott McMeel & Kevin Sweet, 2016; B. J. Meacham, 2010a). Furthermore, where the building officials are not knowledgeable about the proposing innovation, it may cause time and money (Duncan, 2005; B. J. Meacham, 2010a), thereby making innovation disadvantaged.

Performance-based building code comes with a flexibility clause that allows building code users to implement innovative solutions (Becker, 2008; Coglianese et al., 2003; Duncan, 2005; May, 2003). However, when this flexibility is not adequately regulated with an emphasis on accountability and liability, it could cause unintended catastrophic situations such as weather tightness experienced in New Zealand and other similar cases in the United States, Canada and the United Kingdom (Hunn, Bond, & Kernohan, 2002; B. Meacham et al., 2005; Meeks & Brannigan, 1996; Mumford, 2010).

The primary aim of building code is to promote the property, health and safety of the public; however, it seems challenging to assess the point where the introduction of an innovative clause in performance-based regulation crosses the line with safety. B. J. Meacham (2010a) noted that health and safety performance is lacking in some building designed with innovative methods. Further, Meacham (2009) acknowledged that there exist deficiencies in building safety, while (Babrauskas, 2000) pointed out that the drop in safety level is the consequences of transiting to performance. The deficiency also could be a result of parallel interpretations to performance criteria.

3.4. Innovation in building code and the way forward

Innovation in building code brings flexibility (Armstrong et al., 2017; Bowen & Thomas, 1997; May, 2003; MBIE, 2016c), allows new technologies and encourages solutions that would not have been possible with conventional building regulation (Duncan, 2002a; Maugard, Duffaure-Gallois, & Rubinstein, 1998; B. J. Meacham, 2010a). However, some unintended consequences and barriers limit the potentials that come with innovative solutions. The way forward for innovation in performance-based regulation requires the elimination of these limitations.

Extensive training of the building code users and the regulators of building control system are essential (John R. Duncan, 2000; B. J. Meacham, 2010a), as innovative solutions are still developing in the building industry (B. J. Meacham, 2010a). Accordingly, both the building code users and the regulators need a high level of competence and training, as innovative methods may be complex with regards to the technical requirements and assumptions (Cooke, 1979; Dermott McMeel & Kevin Sweet, 2016; Gann, Wang, & Hawkins, 1998; Martin sexton & barrett, 2005; B. J. Meacham, 2010a). Also, an engaging consultation between the regulators and the regulated in the building industry are essential for a successful application of innovation solution in performance-based building code (Raman, 1997). Hence, training would educate the building code users on how to apply innovative solutions in design, construction, compliance and other related issues. Further, the training will equip the building officials with the best practice to assess performance criteria for innovative methods in accordance with the building code requirements.

Duncan (2005) acknowledged that innovative methods should be subject to customers satisfaction and societal expectations. However, these innovations have to be balanced with safety in other to achieve a resilient built environment. Balancing between safety and innovation ensures that innovative solutions are well guided to minimise any possible errors. It is inevitable to achieve a balanced, innovative solution with safety without the required regulatory system. Hence, there is no need to apply innovative methods when the regulatory system and the regulators are not in support of it (John R. Duncan, 2000). However, the regulatory system could be amended to accommodate the use of an innovative solution where safety can be prioritised.

In delivering the kind of built environment anticipated by the relevant stakeholders in meeting the societal expectation using an innovative solution, well-defined regulations that are implementable is needed. In some cases, too rigorous regulations hinder the growth of innovation in the UK and the USA (Eisenberg, Done, & Ishida, 2002; Gann et al., 1998), which led to criticism against regulation (Porter, 1990). To achieve the primary objective of performance-based building code on innovation, the building sector needs an efficient building regulatory system that encourages innovation while ensuring buildings are safe, healthy and durable (MBIE, 2019b). Hence, there is a need to have building code requirements that are understandable and can be applied practically by the users.

Complying with the building code requirements when using innovative methods could be challenging. Hence, there is a need for the third party to independently cross-check designs, construction and products before certification (B. J. Meacham, 2010a). The review process would ensure that competence, quality and performance criteria's are raised to maintain safety in the built environment while encouraging innovation. The independent reviewers will be professionals who are certified by the appropriate entities with the aim of reducing any risk of errors (B. J. Meacham, 2010a), especially in the design of complex structures (Cooke, 1979). Developing a robust verification method and alternative solution that can accommodate more innovative solutions including complex designs and constructions methods would encourage the building code users to use innovative ideas and boost the knowledge of the regulators in approving such designs.

3.5. Barriers to innovation in the building industry

Building with innovative methods is crucial in the construction industry, especially as the globe is fast advancing with technological ideas. The application of these innovative method determines to what extent it would be successful if enabling environment is provided with adequate facilities. Hence, eliminating the barriers that limit the innovative potentials could increase the success rate of innovation embed in performance-based building code. Furthermore, these barriers to innovation in the building industry could be as a result of unexpected changes attributed to the innovative approach.

Accordingly, the lack of preparedness to take care of unexpected changes that might come with innovation could amplify the barriers to innovation (Armstrong et al., 2017). In the context of New Zealand, B. J. Meacham (2010a) reported that innovation was introduced into the system without effective supervision that later led to poor designs, construction and construction materials and products that are not up to the required performance level, as stipulated in the building code. Inadequate supervision may be because of less experienced professionals in innovative practices relating to the design and construction method. Also, due to difficulties in verifying innovative designs, it has primarily been pinned to the expert's interpretation (B. J. Meacham, 2010b), which led to having a different interpretation on one subject (Duncan, 2005; Lundin, 2006; Meacham Brian J., 2008). Multiple interpretations could exist where the building code requirements and regulations may be rigorous, as innovative solutions are still undergoing development.

In some cases, the building requirements are not clearly defined to show the performance criteria (Saunders et al., 2012), which may lead the building code users to make some technical assumptions that are not fact-based (Gann et al., 1998). However, regulations in the building industry could improve innovative methods when rightfully applied. Hence, building requirements and regulations should be used to assist in improving and promoting the use of innovative methods rather than hampering the development (John R. Duncan, 2000).

Many building code users still operate with a prescriptive-based mindset while using performance-based building code, while some building officials also use prescriptive regulation mindset in assessing innovative building solutions (Armstrong et al., 2017; Duncan, 2005; B. J. Meacham, 2010a). The use of mindset that is not measurable to the performance-based building code may discourage the use of innovative solutions. However, the prescriptive mindset could be eliminated through training, adequate preparations and awareness among the regulated and the regulators.

3.6. Innovation and safety in the building code

Performance-based building code created an innovative approach in building code practice. There are concerns that some buildings constructed with performance-based code are lacking health and safety measures (B. J. Meacham, 2010a). Following an example of the leaky building report in New Zealand (Hunn et al., 2002), which showcased the need to balance innovation and safety becomes necessary to reduce the challenging impacts associated with innovation in the use of performance-based building code. The issue can be addressed by considering how the innovative clause in performance-based building code is applied both in design and construction with regards to the safety of the occupants and the building.

Balancing innovation and safety clause creates greater productivity and efficiency in the building regulatory system. However, the concept of balancing innovation with safety requires an approach that is understandable by all, procedural and user-friendly centred. This is essential as the performance-based code only specifies the functional and performance requirements for building constructions and other related works. In Figure 3.1, the factors that contribute to balancing innovative methods and safety is illustrated.

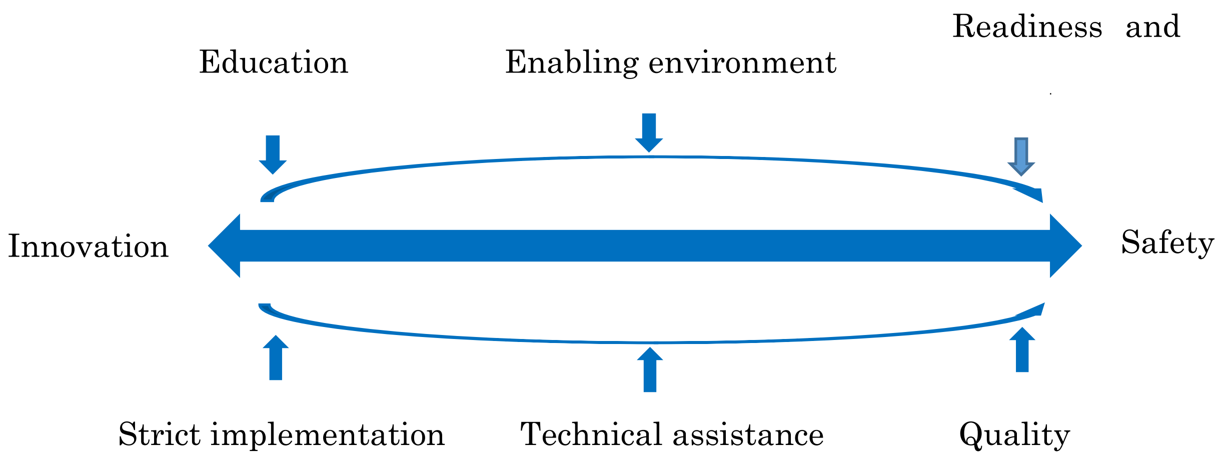


Figure 3.1: Balancing innovation and safety in the building industry.

The safety clause in the building regulatory system may always be affected whenever innovation concept in performance-based code is applied without adequate information and training of the users. This is evident in the case of the leaky building saga in New Zealand, as the new system of performance-based building code was not fully understood both by the users and the regulatory team

(Duncan, 2005). MBIE (2018c) noted the deficiency in knowledge and training gap in the building code system of the country. Hence, recommendations following the incidence were majorly centred on having proactive training and awareness sensitisation at all level (Duncan, 2005; B. J. Meacham, 2010a). Apart from educating code users, providing adequate technical assistance helps the code users to apply caution while receiving external help on fulfilling the code requirements. However, without such provision, balancing the technological advancement under performance-based building code against safety precautions may be problematic.

It is important to recognise the place of providing sustainable policy and creating an enabling environment that would guide the use of innovative methods under performance-based building code. The policies should be interpretative, functional and enforceable within the building control system. This approach will encourage strict implementation, which could help in minimaxing the impact innovation may have on safety. Similarly, regulating innovation to improve safety measures demand quality construction materials and products. Considerably, innovation may have unintentionally affected safety requirements stipulated in the building code regulations; however, innovation has improved the performance of the building regulatory system.

3.7. Conclusion

The benefits and unintentional impacts of innovative concepts embedded in performance-based building code are critically analysed to improve safety and building performance throughout the building life cycle. The study reviewed the need for technical guidelines, proactive training and innovation impact analysis to enhance building performance in the built environment. Innovation under performance-based building code may have affected the safety precautions unintentionally as a result of the flexibility clause; it has also provided some performance efficiency and encouraged the implementation of new concepts required to drive the building industry. However, the study identified the barriers to innovation as it centred on how to verify the innovative solutions, both designs and construction materials and the fear of liability. Duncan John (2000) added that innovative ideas may be limited due to barriers created by some building code regulatory system. To this extent, this study advises that the barriers to innovative approaches, including building policies identified in this study, should be eliminated in its fulness.

The study argued that introducing new concepts in the building system requires adequate preparation and enabling interactive environments where the ideas can strive. This could help to reduce the challenging situations in the application of innovative methods.

4. Building code amendment process: A case study of New Zealand

This chapter was extracted from Conference Publication № 3, Proceedings of the 9th International Conference on Building Resilience (ICBR 09), Bali, Indonesia – January 13 – 15, 2020. Paper No.: 201. This chapter aims to answer the research question RQ2 and research objective RO3.

Abstract

Technology improvements, the knowledge gained from the previous disasters and the need to pre-plan for natural hazard events affecting the built environment have created the need for the building code amendments in New Zealand. Following the Christchurch earthquake in 2011 and the Kaikoura Earthquake in 2016, the New Zealand building code has been frequently amended to reduce the impact of natural hazards. The process of the building code amendment poses some challenges on how the code users understand and comply with the amended code. Although, building code amendment is the pathway towards providing a more resilient built environment. However, without a well-defined process incorporating relevant stakeholders, the purpose of disaster risk reduction may not be achieved. This study explores the process and timelines of New Zealand building code amendments, examine ways of improvement, and how the process affects the post-disaster reconstruction in New Zealand. The process of the New

Zealand building code amendment process was examined through integrative literature review and conceptual context. This study highlights the need for improvements in the building code amendment process in New Zealand and the incorporation of all relevant stakeholders. The improvements will help to address the issue of non-compliance to building code and promote the importance of amendments to code regulations. The study also demonstrates that a well-managed building code amendment process could enhance resilience to New Zealand buildings during any natural hazard event. The study concludes that building code amendments do not reduce the impact of disasters, but strict enforcement, implementation and compliance of the amendments are more likely to reduce the impacts.

4.1. Introduction

New Zealand is geographically located in an active seismic zone that incorporates other forms of natural hazards such as flood, tsunami, volcanic eruption, landslide, coastal erosion and tornado. Situated in such an environment, the country has developed a good working building code over the years to reduce the impact of disasters and truncates natural hazards from becoming a disaster. The New Zealand Building Act was enacted into law in 1991 and enforced in 1992, although there were building regulations in the country since 1842 (Nigel Isaacs, 2011), administered by different municipal authorities (Nikki Buckett, 2014). However, the New Zealand Building Act was revised in 2004 as a result of significant building quality and deficiencies, majorly in the innovation aspect that created the leaky building saga in 2003 (Hunn et al., 2002; Mumford, 2010). The 1991 Building

Act became necessary following the leaky building saga to restore public confidence in the government and truncate design and construction failure in New Zealand. Hubbard Dennis and Timothy M. Pastore (1997) reported that some members of the Building Industry Authority in charge of the New Zealand building code did not provide adequate information when the building code was first implemented due to lack of finance. This could explain the main reason behind the noticeable deficiencies in the building code requirements. The findings from (MBIE, 2015), indicates that poor monitory, lack of information flow, inadequate incentives, poor performance caused by lack of coordinated liability, lack of clarity and unclear roles and responsibilities of building code stakeholders created problems in the New Zealand building regulatory system.

Furthermore, the New Zealand building code passed through many amendment processes to ensure easy practice, improved innovation and promote resilience in the built environment. Some of the amendments were triggered after the 2011 Christchurch earthquake and the 2016 Kaikoura earthquake, with new documents added to the building code. Other factors that triggered building code amendments include but not limited to knowledge gained from the previous disaster, improved technology, and discovered technical requirement deficiencies in the building code (Nwadike et al., 2019a). The building code aims to promote safety, good quality, affordability of houses and grows investment by setting the performance standards of all building construction in New Zealand (MBIE, 2017a). Nikki Buckett (2014) noted that the New Zealand building code is amended in line with the political changes, society expectations and advancement in construction technology. New Zealand building codes have traditionally been amended over various timeframes without specified intervals (Nwadike et al., 2019a). However, MBIE (2018b) recently announced and implemented a biannual amendment process. The announcement was the result of noticeable deficiencies on the part of the regulators in managing the irregular updates and to give the building code users and building owners space to keep up with changes.

IRC (2010a) believes that a transparent public review process of the building code amendment gives all relevant stakeholders an opportunity to participate and offer their respective opinions. This suggests that the process could determine the rate of acceptance and compliance of the stakeholders to the amendments. Hence, the building code amendment process is an integral member to achieve a resilient built environment and should be handled with all carefulness.

This paper examines the process and the timelines of the New Zealand building code amendment process, check how the process can be improved and explore the post building code amendment challenges in the built environment. The focus of the study was achieved through an integrative literature review and conceptualised context.

4.1.1. Research objectives

i. To explore the process of amending the New Zealand building code.

ii. To examine the post building code amendment challenges in New Zealand.

iii. To make recommendations on how the building code amendment process can be improved to reduce the identified challenges.

4.2. Overview of New Zealand building code

Building regulation started in New Zealand in 1842 called Raupo House, and was drafted based on fire effect (Nigel Isaacs, 2011). The building regulation started as a prescriptive-based building code that states the step-by-step procedures for design and construction requirements as stipulated in the building code. This later metaphase to performance-based building code in 1991, following the report of the Building Industry Commission in 1986 (Nikki Buckett, 2014). The New Zealand building code was partly derived following the Norwegian building code (Nikki Buckett, 2014). The New Zealand performance-based building code followed the five Nordic model hierarchy, which provides the structure of the code, as shown in Figure 4.1.

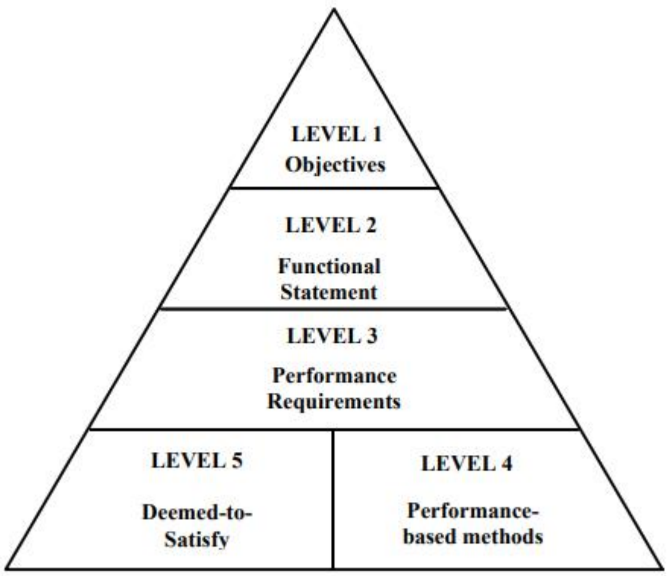


Figure 4.1: The Nordic hierarchy model followed by the New Zealand building code (De Almeida, Sousa, Alves Dias, & Branco, 2015).

New Zealand building code has a unique structure that comprises the Building Acts, building regulations and the building code with objectives, functional requirements and performance requirements that describes the technical clause of the building code as shown in Figure 4.2

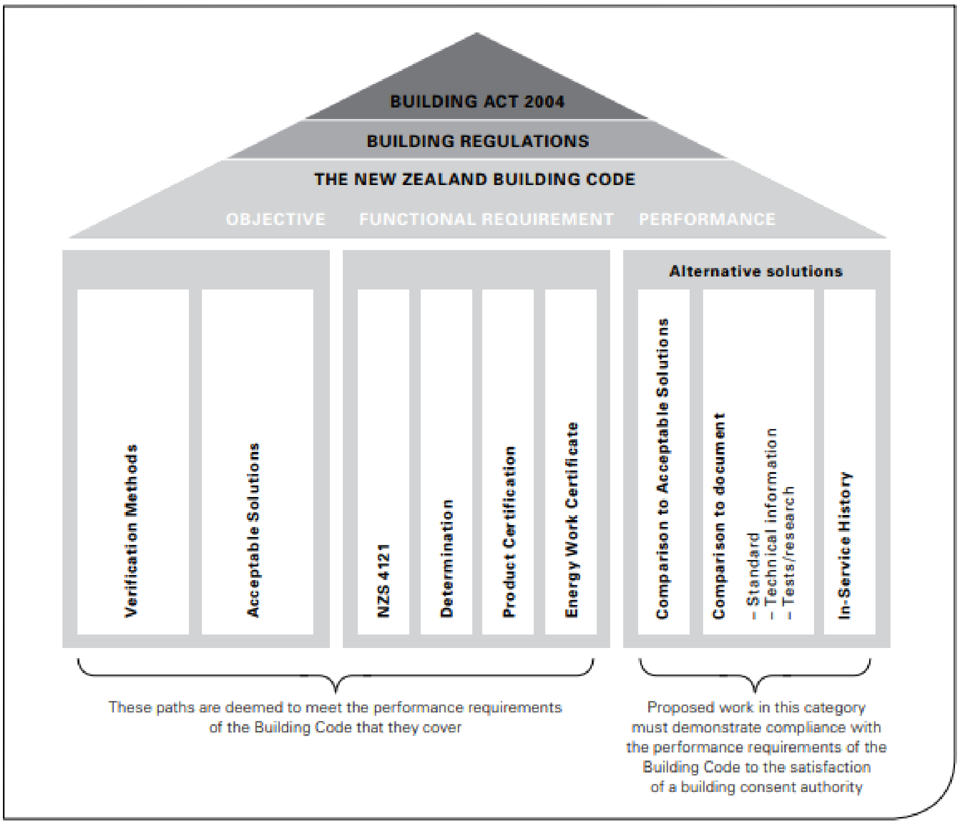


Figure 4.2: Building control regulation framework (MBIE, 2014b).

MBIE (2014b) defined the functions of each of the categories of the building control framework in details. The framework has three pathways to achieve compliance with the New Zealand building code, which are: (i) acceptance solution. (ii) verification method and (iii) alternative solutions. In demonstrating compliance with the New Zealand building code, one or more of the above compliance pathway can be used. However, any pathway followed, the building consent officer must be satisfied that the method fulfils the performance requirements of the building code (MBIE, 2014b). The MBIE is the primary regulator of the New Zealand building code, although other agencies contribute to the regulatory process in the form of a quasi-regulatory role (MBIE, 2016d).

4.3. Drivers of building code amendment

Building code requirements are dynamic, as natural hazard events are not static. It requires a regular amendment to provide current guidelines on the design and construction of buildings and to protect lives and properties. It is a formal process that needs to be triggered before the initiation process can start (IRC, 2010a). The amendment process can be activated by the building consent officer, the government, the industry or the public. Hence, ideas are accepted from all angles. Although, there are drivers of building code amendment, under which anyone can make an official request for amendment, as shown in Figure 4.3. Nevertheless, the regulatory body committees must assess the reason for the amendment before calling for the process. These drivers are significant and aim at achieving building resilience in the built environment.

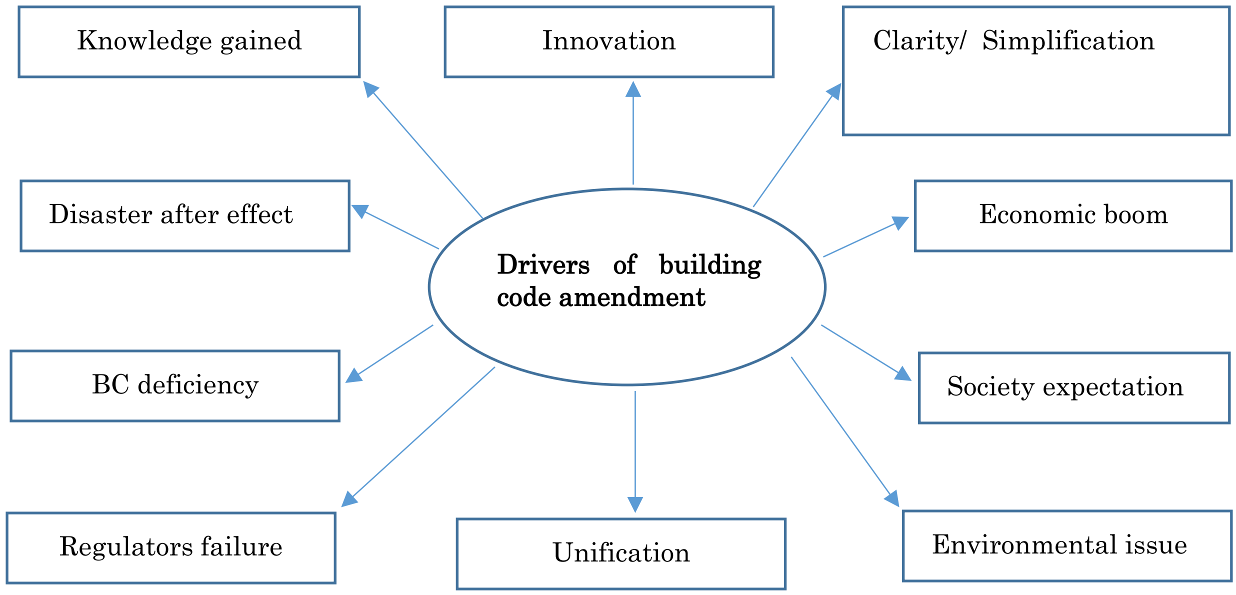


Figure 4.3: Drivers of building code amendment.

The drivers that prompt for building code amendment could be positive or negative; however, it aims at improving the quality of the building to reduce the natural hazard challenges facing the built environment. Building code amendment creates an enabling environment to replace outdated building code requirements with new provisions that are more cost-effective and innovative to meet up the societal expectations of having a resilient built environment. In these derivers lies the purpose of amending building code. NCBCS (2018b) reported that knowledge gained society expectations, and the introduction of new technological concepts prompted building code revision in the United States of America. Without the amendment, the building code will remain static and incapacitated in responding to the societal and industrial changing needs (NCBCS, 2018b), which might cause a loss of truth on the building code. Learning from knowledge gained in the previous disaster could slow down the rate of responsive nature of the relevant stakeholders in pruning the effect of the natural hazard before it turns into a disaster. Many building code amendment processes are because of gained experiences from past natural hazard events (Hasegawa, 2013; Maki & Hayashi, 2000; Spence, 2004). In some countries, such as Canada, clarity and simplification of the building code drives the code revision (IRC, 2010a). Simplifying the building code for clarity demands for intensive education of the building code users and the building consent officers. In addition, MBIE (2015) acknowledged the complexity in using New Zealand building, and have outlined various approaches to simplify the building code to enhance compliance. Deficiencies were identified in the building code requirement as the primary driver of Turkey building code amendment following the 1999 Kocaeli earthquake in Turkey (Johnson et al., 2000). Notwithstanding, Gülkan et al. (1999) opined that the previous revision of the Turkey building code was responsible for the building collapse in the 1999 Kocaeli earthquake. The amendment made the technical requirements and compliance too complex for design professionals (Gülkan, 2001), which suggests that after building code amendment, it could require skilled professionals for implementation.

4.4. The process of New Zealand building code amendment

The process of amending building code in New Zealand follows a well-defined systematic approach that aims at improving the quality of buildings, safety and reduce the complexity of the technical requirements of the code. The amendment procedures are in stages, as shown in Figure 4.4. Furthermore, different countries use diverse procedures aimed at having an efficient regulatory system that can reduce the impact of a disaster in the built environment.

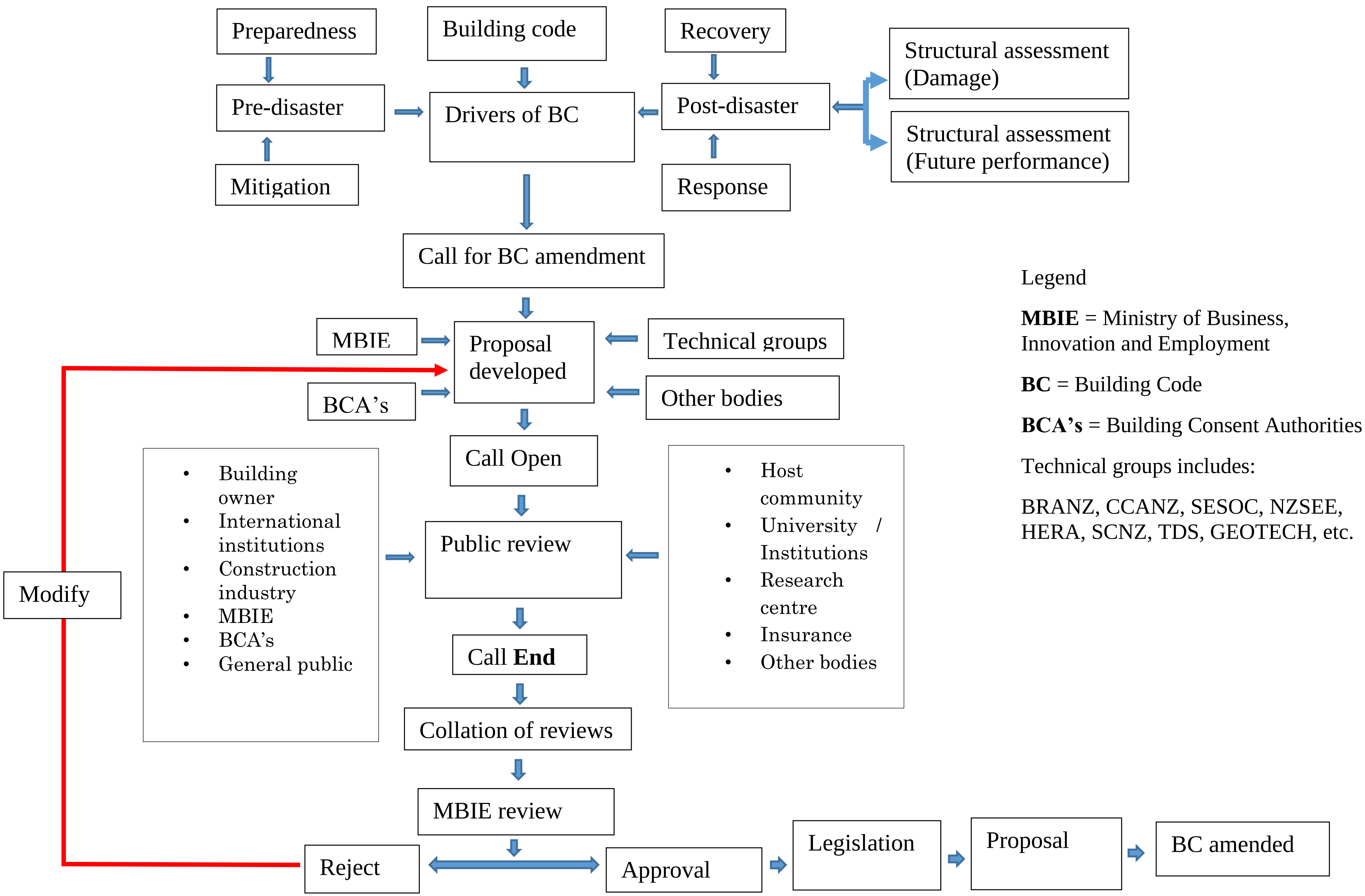


Figure 4.4: New Zealand Building code amendment.

4.4.1. Need Identification and submission

The procedure allows for the submission of a proposal to change the existing building code or associated compliance documents. The need for building code amendment must be identified, and the call for a change must proceed with outlining the deficiencies in the existing building code, the effects of the deficiencies, the reasons for necessary changes, how it can be achieved and how the new proposal can comply with the requirements of the Building Act. Anyone can request for building code amendment in New Zealand, provided there is substantial evidence to back up the proposal. According to ABCB (2013), the proposal for change must show a detailed description of the proposal, proof of insufficiency in the existing building code, how the proposed changes can solve the identified weakness, which the changes will affect and the related impacts. Furthermore, ABCB (2013) explained that changes to the Australia building code are initiated through the use of a standardised questionnaire administered by the Australian Building Code Board. Once the proposal is submitted, the MBIE and other regulating agencies will cross-examine the proposal and assess if there is any deficiency in the existing building code. On acceptance of any shortcoming in the building code requirement, the call for public review will be declared open. The initial review helps the regulating bodies to be focused on their quest to improve the building code. The approach is in line with the building code amendment process in Canada (IRC, 2010a). The MBIE reserves the right to amend the submitted proposal to suit the objectives of the Building Act.

4.4.2. Consultation and public review

The MBIE calls for review and consultation to the New Zealand building code twice every year (MBIE, 2018b). The public consultation is opened between February/March and August/September each year. The outcome of the amendment exercise are programmed to be published on 30 June and 30 November each year. The MBIE notifies the public through the use of email, posting the review period on their websites, placing a notice in key publications, and informing various technical groups. At the end of the consultation period, the reviews are collated by MBIE for further detailed interpretation. Open consultation and collaboration in amending building code generate benefits to all relevant stakeholders (Lovegrove, 1991). It sets the pathway for truth and transparency in reviewing building (Croley, 2009). However, consultation may not necessarily lead to a good regulatory process (Burgess & Thomson, 2015), because it may be biased in a situation where the process is outnumbered by certain interest group (Croley, 2009).

4.4.3. MBIE post-public review

After the public review process, the MBIE analyse each comment in line with the aim and objective of the proposal for amendment and the Building Act. Based on the outcome of the review, the proposal may be rejected and returned for modification or accepted for approval. Sometimes, the proposal could be withdrawn. Before approval, all concerns regarding the proposal are cleared to encourage compliance with the new changes.

4.4.4. Legislation process

Following the approval of the proposal by MBIE, the changes are legislated into law. Legislating the amendment into law means that every building code user must recognise the changes and comply accordingly. The changes are made available for use. After enacting the approved amendment, a specific date is scheduled when the changes will be effectively implemented. The gap between the approved period and the date of application creates room to educate the building code users and the building consent officers on how to apply the new changes. Hence, this paper concludes that before enacting the changes into law, the building code users should be well educated and informed regarding complying with the changes.

4.5. Challenges of post building code amendment

Amending building code has yielded many positive results in response to minimising the impact of natural hazards in the built environment and improving innovation in the design and construction industry. However, the aftermath of a building code amendment could be challenging, especially where adequate consultation was not carefully carried out. Leaky building incidence in New Zealand is an example of the post-building code amendment (Mumford, 2010). In most cases, the post-building code amendment challenges depend on the process of amendment, how the code users are educated and the willingness of the local authorities to enforce the new changes. The dedication and readiness of all the relevant stakeholders in achieving the purpose of a building code are required to reduce the post-building code amendment (Nwadike et al., 2019a). Some of the post-building code amendment challenges are discussed below.

4.5.1. Non-compliance with building code

Compliance following building code amendment is challenging regarding implementation in design and construction practice. These challenges could be a result of the inability of the building code users to understanding and interpreting changes made to the building code. Jones and Vasvani (2017b) believed that the lack of understanding of the changes to the building code significantly increases the level of non-compliance. Improving the building code indeed increases the safety level; however, (Heijden, Visscher, & Meijer, 2007) it can make building code to be too complex following implementation. Also, Spence (2004) agreed that it amplifies more in areas with lower technical capacity. Therefore, Spence (2004) advised for building code simplification to increase the compliance rate through the use of the amendment process. Notwithstanding, the New Zealand building code is amended regularly to have a responsive building code that is easier to comply (MBIE, 2019h).

4.5.2. Lack of enforcement

In normal practice, building code amendment follows enforcement to ensure that the changes made to the building code are effectively implemented. The efficiency of the enforcement largely depends on the willingness of the local building authorities to enforce the changes and their ability to comprehend the changes before enforcing the changes. NCBCS (2018b) recommended more involvement of building consent officers in building code amendment to increase enforcement.

FEMA (2019) noted that enforcement of building code following any amendment helps to reduce the impact of natural hazards in the built environment. Furthermore, without enforcement of the changes made to the building code, the code does not have any significance (Pilzer & Jasuja, 2005). Moreover, Burby and May (1999) reported inadequacies in building code enforcement following each amendment of building code. Hence, both the code users and the building consent officers need to be educated following every building code amendment.

4.5.3. Increase in construction and design cost

It is obvious that cost following building code changes play a significant role in the regulatory process in achieving the purpose of building code practice in the built environment. Improving building code either increase the cost or reduces it, depending on the parameters put in place before amending the building code. Building code amendment always comes with an increase in cost (David Kelly, 2012; Khan Raza Ali, Uneb Gazder, & Fawwad Masood, 2010), that spread across the design, construction, inspection and administration stages. David Kelly (2012) further stressed the implementation cost with an emphasis on educating building code users and the regulators, following any changes made to the building code. Deighton-Smith and Jacobs (1997) noted the impact of cost due to building code changes and highlighted the need for cost-effectiveness analysis before amending building code. NCBCS (2018b) recommends developing an efficient cost/benefit tool for easier building code amendment process and compliance. The cost of compliance and complexity of building code amendment application have led some low-income local authorities to abandon their codes and align to other building codes without amendment (Listokin & Hattis, 2005). The cost of implementing the building code requirements could deter the building code users from complying with the changes.

4.5.4. Lack of awareness and training

Awareness and training of building code users are among the priority factors that should follow any changes to the building code. Creating awareness of the amendments made to the building code helps the code users to know the changes and their importance in reducing the impact of natural hazards while educating the building code users make them know how to implement the changes effectively. For a successful implementation of building code amendment, a well-organised training programme must be conducted for all building code and the building consent officers to increase their level of understanding, respectively (Duncan, 2005).

Furthermore, educating building code users should be a dynamic process that will involve a systematic evaluation of their understanding of the changes made to the building code. This will increase implementation and voluntary compliance. Inadequate training (Burby & May, 1999; Dixit Amod & Esteban Leon, 2009), lack of adequate knowledge of the building code (NCBCS, 2018b), limited understanding of building code changes (Jones & Vasvani, 2017b), and lack of public awareness (Olshansky, 1996) are among the post-building code challenges that limit the significances of building code amendment, and hence, requires attention. Findings from Chmutina and Bosher (2015) indicated that understanding the requirements of the building code improves the level of compliance. Accordingly, well-focused training and awareness are as significant as amending building code regularly (Spence, 2004). This is evident when implementing changes made to building code without sufficient training and required information, as it is in the case of the 2002 leaky building incident in New Zealand.

4.5.5. Building code complexity

Improving building code as a measure to ensure health and safety in the built environment could make the requirements of building code more complicated. The complexity could lead to poor design and construction practice, especially among building code users with little professional skills. Reducing the complexity in building code through a user-friendly approach (Dixit Amod & Esteban Leon, 2009) increases building code efficiency and compliance level (David Kelly, 2012). Following the 1997 building code amendment in Turkey, Gülkan (2001) reported that most of the building code users believed that the 1997 amendment made the building code too complex to use. These complexities in building code exist as a result of the process of updating building code, complications in building design (McLean, 2017) and the increase in the dynamic response to the persistent natural hazards that occur in the built environment. However, code complexity can be reduced by having a well-defined compliance pathway that enhances clarity, user-friendly, future-focused and quality performance that is consistent (MBIE, 2018c). Likewise, minimising code complexity largely depends on the building code regulators and the government.

4.6. Conclusion

This study explored the process and timelines of building code amendment using New Zealand as a case study. The study suggests that improving the process of building code amendment process would help to address non-compliance with the code requirements. Furthermore, the drivers of building code amendment highlighted in this study may depend on location, building code in use and societal needs. The study demonstrated that a well-managed building code amendment process could enhance the resilience of New Zealand buildings.

Although the New Zealand building code amendment process is well-managed to an extent, there is a need to train and provide technical assistance to the building code users after the amendment process. Also, the building code regulators, other agencies and the associated technical groups need to be more open to individual opinions while ensuring a zero-bias process. Also, the study showed that there are some challenges following building code amendment. Future research could consider how to reduce the challenges of the post building code amendment process.

Transparency and inclusiveness in the building amendment process would help to create a mutual relationship between the regulators and the regulated. The transparency and inclusiveness would ensure the active participation of all relevant stakeholders. Moreover, the MBIE needs to ensure that the primary purpose of amending the building is maintained throughout the amendment process.

5. Building code amendment and building resilience: A perspective of building code users in New Zealand

This chapter was developed from Publication № 4, Published in the Built Environment Project and Asset Management journal. DOI: https://doi.org/10.1108/BEPAM-02-2020-0020. This chapter aims to answer the research question RQ2 and research objective RO4.

Abstract

The process followed in amending building code creates problems for code users within the building industry. These problems include; the need and frequency of changes made to building code, access to updated documents, method of communication, amendment interval, and amendment pathway. This study aims to explore the viewpoints of building code users regarding building code amendments in New Zealand. Using a closed-ended questionnaire survey, this paper examined the New Zealand building code amendments by evaluating the views of experienced and relevant stakeholders within the research area. A high proportion (50.90%) of the survey participants agreed to a three-year building code amendment cycle, as against the current biannual Amendment practised in New Zealand. Findings from the study affirmed the necessity for building code amendment and the support for free amended building code documents to the public and other building standards. The study concludes with strong support to

the use of intensive research and learning gained from disasters in building code amendment in New Zealand. Implementing the code users opinions encourages disaster resilience through effective application of the building code requirements in design and construction.

5.1. Introduction

New Zealand is geographically located in an active seismic environment that has experienced several disasters. The hazard impacts in the built environment, including fire and earthquakes, created the need for the first New Zealand building legislation (Nigel Isaacs, 2011). The use of the building code has gained positive results (Ainuddin, Mukhtar, & Ainuddin, 2014; Spence, 2004), by fulfilling the code requirements. Continuous use of the building code as a measure to reduce natural hazard impacts require a regular Amendment. Regular amendments of building codes have been emphasised in the international context, including the UNISDR (2015b) highlighting the importance of building code revision both for the existing and newly developed building code. In Japan, building code passes through the amendment process following every earthquake to ensure a resilient built environment (Maki & Hayashi, 2000).

In New Zealand, the building code is frequently amended. These Amendments has provided unique opportunities to improve on the building requirements, remove outdated documents, introduce new technological concepts, review innovation, improve safety requirements, simplify the process of compliance and enforcement. Lawrance, Hopkins, Cheong, and Stannard (2014) noted that the deficiency in measurable performance requirements in the buildings facilitated the country building code amendments.

While the building code may be serving its purpose quite well, there is a need to consider the opinions of code users to raise awareness on pressing issues within the regulatory system regarding the process of regular amendments, to improve the resilience of buildings in the built environment, and enhance the application and use of building code requirements. A close examination into the viewpoints of New Zealand's building code users is, therefore, timely to promote the effectiveness of the building code amendments for its users, as there is no empirical evidence that has considered the view of its users regarding its frequent amendments. The correction and implementation of building code users concerns are resourceful in improving disaster resilience while reducing disaster impacts.

This study evaluates the opinions of New Zealand's building code users regarding the frequent amendments and the method of assessing the building code information. Findings from this study will inform the building code regulators and the associated agencies about the views of building code users on the frequent amendments. The study also shows the best channels of communicating information regarding building code amendments.

5.2. Building code amendments and its advantages

Building code amendment in the context of this paper can be defined as an improvement to either the building code or the associated compliance documents to increase the building resilience in reducing disaster impact inspired by natural hazards. Building code amendments could occur in the form of adding new documents, making corrections to the existing documents, and discontinuing from existing building or construction materials into the construction market (Nwadike et al., 2019a; Thompson, 1947). This Amendment brings new changes aimed at improving the building performance (Lawrance et al., 2014), and setting a clear definition of the minimum standards (Carla Williams, 2016). Moreover, New Zealand's Ministry of Business, Innovation and Employment has acknowledged the usefulness of building code amendments in setting a clear definition of ultimate capacity and other terminologies in the Building Act, building code and other building standards (MBIE, 2016g).

Amendment to the building code helps to bridge the gap between building code requirements and the code users, and identify potential factors that will enhance disaster resilience (Ahmed et al., 2018), and promote safe buildings that are durable, robust and efficient (MBIE, 2019f). Regular amendments to the building code and the associated compliance document provide an opportunity to make the code more user-friendly by increasing its performance, standards for infrastructures, support for innovation in the building system, and providing sufficient detail to performance requirement through the Building Act requirements (MBIE, 2014b, 2019g). Building code amendment increases the level of compliance with building code while offering broader sustainability measures for a safer built environment (Ahmed et al., 2018). Updating the building code would aid its improvements and simplifications of compliance documents and alternative solution performance requirements. Building code amendment has opened up new horizons to incorporate knowledge gained from previous disasters into the building regulations (Nwadike, Wilkinson, & Clifton, 2019d). However, before amending the building code, careful considerations should be given to the applicability of its intended changes (Lawrance et al., 2014), including the unintended consequences of the changes. Besides, building code amendments require adequate attention in regulating the type of construction materials used, and the skills of the professionals that will make use of the materials. Effective regulation of everything relevant to the construction industry could facilitate the primary purpose of building code amendment.

5.3. When is the best time to amend a building code?

The question regarding when building code amendment should be carried out is still a controversial issue globally. While some previous studies may have suggested a 3-years cycle as the best time to amend a building code (IBC, 2006; NCBCS, 2018b; Spence & Kultermann, 2016; Vaughan & Turner, 2013), others have suggested a 5-years cycle (IRC, 2010a). Some countries such as Japan and New Zealand update their respective building codes following every disaster triggered by a natural hazard (Maki & Hayashi, 2000). However, New Zealand shifted to a bi-annual amendment cycle in 2018 (MBIE, 2018b). Accordingly, there is no consensus interval for building code amendment around the globe. Regardless of when building code should be amended, the primary aim of the Amendment from different studies remains to improve the code, health, property, life safety and encourage innovation-driven through research, gained experience from previous disasters, or both (Bergeron, 2008; David Kelly, 2012; IRC, 2010a; Nwadike et al., 2019d). Although there is no acceptable amendment interval globally, building code amendments require adequate preparation and should be done regularly to keep building codes and building standards up to date (Nwadike et al., 2019d).

Nikki Buckett (2014) pointed out that cost and benefit assessment is essential for a robust positive outcome of building code amendments. All amendments to the building code and the corresponding compliance documents need to be approved, recorded and enforced by the appropriate authorities, such as the building consent authorities (MBIE, 2006). It is always the responsibility of code users to track and implement any amendment to the building code. However, the regulators and the appropriate authorities should inform, explain the reasons for the proposed amendment before allowing anyone to participate in the variation process.

The efficacy of building code amendment may largely depend on the effectiveness of its implementation, enforcement, and compliance with the building code and requires the establishment of a dedicated committee comprising relevant professionals. Building code amendment may be important, but to what level of expectation should the Amendment be aiming for?. This is a question that needs to be answered by the building code regulators before any amendment is made to it and other relevant building standards. Lawrance et al. (2014) have pointed out that amendments should be able to meet a society's expectation with emphasis on safety, public health and the resilient built environment. Developing a building policy to determine the acceptable risk tolerance of a society is necessary before any building code amendment (Lawrance et al., 2014).

Recently, the New Zealand government launched a bi-annual building code amendment process (MBIE, 2018b). The MBIE (2018b) admitted that irregular updates of the building code contributed to the lack of clarity experienced by its users and the inconsistency and uncertainty to the needs of the New Zealand construction industry. Consequently, the MBIE makes adequate consultation with the building code users before proceeding to the amendments process.

Previously, the New Zealand building code went through several amendments since the Building Act was enacted in 1992, reviewed in 2004 and 2016, without any specified interval. The 2004 Building Act amendment introduced laws governing building works (MBIE, 2004), because of the leaky building crisis (Mumford, 2010). Following the building performance in the 2011 Christchurch earthquake and the 2016 Kaikoura earthquake, the 2004 Building Act was amended in 2016 relating to improvement in building controls with an emphasis on earthquake-prone buildings (MBIE, 2004, 2016i).

5.4. Public perception regarding building code application

The concept of improving the application of building code requires the input of different stakeholders, of which the building code user's opinion is a factor to be considered. Within the context of this paper, building code users are referred to as the building professionals that apply and use the building code. Since the building code was developed to improve the resilience of the built environment, then the contributions from its users should not be overlooked. Smith (1971) suggested that public opinion is a product of an individual's belief along different lines. Constructive ideas could help in improving the building control system when evaluated objectively rather than subjectively or ignoring the opinions. Depending on a targeted audience, building code users opinion influences and shapes a system in the right direction by providing insight and public viewpoints on building code related matters (Keith Manch & Peter Burke, 2011; Smith, 1971). Building code user's opinion could, therefore, be considered as a significant aspect of the building code amendment process.

The building code resilient cycle requires the user’s opinion, regulators action and regular building code amendment within a specified interval. This could help to improve the resilient built environment. Figure 5.1 shows how building code user's view can contribute to a better resilient built environment.

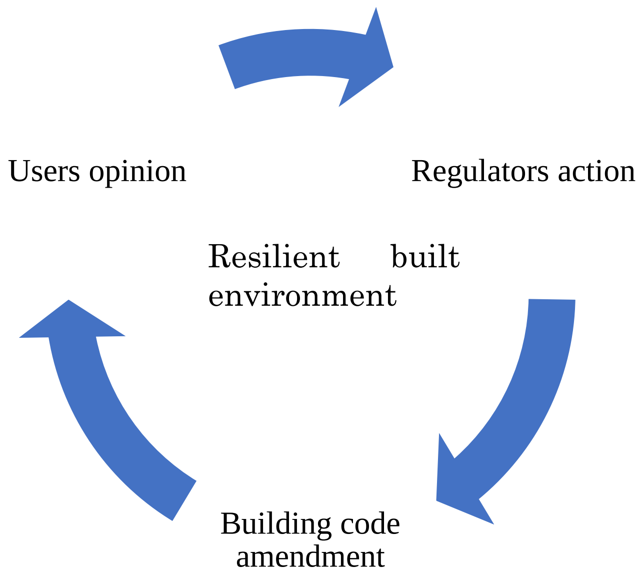


Figure 5.1: Building code resilient cycle.

Furthermore, public opinions may be in support or against a system (Valentin & Bogus, 2015); in whichever way, it provides a means to evaluate the performance of building code application. In context, building code user's opinion, if utilised, can become a balancing factor in building code regulation. The government of New Zealand is beginning to recognise the significance of public contributions and feedback in improving building code (MBIE, 2019g). However, the integrity of public opinions regarding improving building code may be questionable due to likely manipulations of the process (Kitomulo, 2017).

5.5. Significance of ease of access to New Zealand building code and standards

Building code and other associated standards usually provide guidelines for the construction industry. Consistent underperformance of buildings threatened by natural hazards has necessitated the growing need for building code amendment. However, the ease of access to these amended building codes and standards to the public has been a subject of debate (Bill Millard, 2019). The government of New Zealand is gradually eliminating compliance barriers by providing free building codes and standards to the public (Jenny Salesa, 2019), to encourage safe building construction (MBIE, 2019d). Accordingly, the provision of free building code and standards to promote the ease of access to these documents attracted about 15,000 downloads within 18 months (MBIE, 2019d). This rate of the downloads recorded by MBIE shows that the ease of access to building code and standards could significantly encourage compliance. Apart from promoting compliance, the enhanced usability of the building code as a projected outcome of ease of access to the documents could significantly promote the application of the latest changes in design and construction, and, maintain high standards (Karen Andrews, 2015). However, Bill Millard (2019) noted that copyright-related issues usually pose some barriers to providing free building code and standards to public users.

5.6. Building code in disaster resilience

The application of building code requirements has been acknowledged as a measure that improves disaster resilience in the built environment (Ahmed et al., 2018; Nwadike et al., 2019d). However, achieving disaster resilience requires effective compliance with the building code (Ahmed et al., 2018; Nwadike et al., 2019d; Ricciarini Sylvana, 2009) and adequate implementation of code requirements. Addressing compliance issues following building code amendment involves seeking the opinions of code users helps to share evident-based knowledge between the code regulators and the code users on the process surrounding building code amendment. Also, it requires making building code more user-friendly, easy to understand, and well-defined compliance pathway (Nwadike et al., 2019d). Hence, the need to understand and seek the opinion of building code users becomes imperative in creating an enabling environment that fosters compliance while improving disaster resilience in the built environment.

5.7. Research method

This study examined building code amendment in New Zealand and the perspective of the building code users. A closed-ended questionnaire was adopted to explore the various opinion and views regarding the New Zealand building code amendment. The rationale for using a questionnaire survey is that it is a relatively cost-effective, fast, and efficient method of gathering a large amount of data within a short period of time (Goodman, 1997; McLeod, 2018). The survey was distributed by hand and online to capture the wider community of the relevant stakeholders that use the building code. The participants were selected across New Zealand based on their immense knowledge regarding the research topic, using the purposeful sampling technique (Babbie, 2013; Neuman, 2014). The purposeful sampling method was adopted because it allows research to be conducted in an environment where participants are carefully selected to contribute meaningful and comprehensive insights on the subject matters (J. A. Maxwell, 2013).

For this study, 250 questionnaires were distributed, of which 121 of the questionnaires were completed and returned, including five incomplete ones. Hence,116 questionnaires were used to analyze the building code users opinion regarding the New Zealand building code amendments. The returned questionnaire in this study demonstrated an acceptable response rate of 48.4 per cent, which is above the average survey response rate of 33 per cent (Fenton-O'Creevy, 1998; Nigel, 2019; Onwuegbuzie & Collins, 2007).

The completed and returned questionnaires were analyzed using the Friedman test in the Statistical Package for the Social Sciences (SPSS) tool. The responses of the questionnaire participants were coded in numbers into a spreadsheet in SPSS software manually and then cross-checked twice to ensure accuracy. The profile of the questionnaire participants is summarised in Table 5.1.

Table 5.1: Participants profile.

Category	Frequency	Per cent
Participants professional group		
Structural engineers	58	50
Geotechnical engineers	11	9.5
Architects	2	1.7
Consulting engineers	2	1.7
Licensed building practitioners	7	6.0
Project manager	15	12.9
Building contractors	4	3.4
Local authority	9	7.8
Academic/Researchers	8	6.9
Total	**116**	**100**
Years of professional experience		
0-5	23	19.8
6-10	34	29.3
11-15	23	19.8
16-20	17	14.7
>20	19	16.4
Total	**116**	**100**
Organisational size		
Large scale	50	43.1
Medium scale	44	37.9
Small scale	22	19
Total	**116**	**100**
Participants organisational position		
Director	24	20.7
Senior management	15	12.9
Middle management	20	17.2
Supervisor	17	14.7
Staff	40	34.5
Total	**116**	**100**
Participants location		
Auckland	45	38.8

Wellington	26	22.4
Christchurch	38	32.8
Dunedin	2	1.7
Others	5	4.3
Total	**116**	**100**

Source: (Nwadike & Wilkinson, 2021).

The null hypothesis for this study is that there would be no significant difference that each question item in the questionnaire would have on the viewpoints of the building code users in the building code amendment process. As a decision rule for this study, the null hypothesis should be rejected if the *p*-value is less than 0.05. The null hypothesis is determined based on data analysis and findings from the Friedman test conducted in SPSS.

5.8. Findings and discussion

The questionnaire survey findings analyzed the opinions of building code users towards amending building code in New Zealand. A five-point Likert scale was adopted to weigh the response of the questionnaire participants (i.e. 1 = Strongly disagree; 5 = Strongly agree). The Likert scale allows the survey participants to express the degree of their opinions regarding the research topic. The rationale for adopting a five-point Likert scale is to provide a better understanding, quality answer, increase the response rate, reduce respondents frustration level and easy way of data analysis and conclusion (Babakus & Mangold, 1992; Finstad, 2010; Leung, 2011; Sachdev & Verma, 2004). The responses from the questionnaire survey analyzed in SPSS are discussed below.

5.8.1. Reliability check

The Cronbach alpha reliability check was used to examine the degree of internal consistency of the items weighed in the questionnaire, for this study (Sharma, 2016; Tavakol & Dennick, 2011). The coefficient of the Cronbach alpha can be evaluated from the following equation:

$$\alpha = \frac{K.\overline{C}}{\overline{V} + (K-1).\overline{C}}$$

Where α is the Cronbach coefficient, K is the number of questions, $\overline{C}$ is the average covariance among the items, and $\overline{V}$ is the average variance of the items.

Findings from the SPSS analysis revealed a Cronbach alpha coefficient of *0.545 > 0.5*. The α value indicates an acceptable moderately reliable level of internal consistency measure of the entire item assessed (Aigwi, Egbelakin, & Ingham, 2018; Dall'Oglio et al., 2010; Hinton, McMurray, & Brownlow, 2014; Sharma, 2016). Besides, the value of a Cronbach alpha coefficient is usually determined by the number of questions and criteria's assessed, which infers that the higher the number of questions and criteria's, the higher the Cronbach alpha coefficient (Sharma, 2016). Tables 5.2 and 5.3 illustrates the result findings from the Friedman test analysis.

Table 5.2: Friedman test results summary.

Case-processing summary			
		Number of participants	**%**
Cases	Valid	116	100.0
	Excluded[a]	0	0.0
	Total	116	100.0

Note: [a]Listwise deletion based on all variables in the procedure. Scale: All items on the perspective of building code users	
Friedman test item analysis	
	Mean rank
Existing New Zealand building act needs Amendment	5.23
New Zealand building code compliance documents needs Amendment	5.39
Free access to building code amendment documents in New Zealand	6.71
Duration of building code amendment	5.71
Preferable pathway for building code amendment	3.23
Getting information about New Zealand building code updates	3.97
Visitor counts to MBIE website in search of building code updates	4.41
Building code amendment following any major disaster	1.35
Test statistics	
N	116
X^2	420.671
df	7
Asymptotic significance	0.001

Table 5.3: Cronbach alpha reliability check.

	Mean	Minimum	Maximum	Range	Maximum/ Minimum	Variance
Item Means	3.267	1.405	4..414	3.009	3.141	0.870
Item Variance	0.769	0.243	1.383	1.139	5.687	0.167
Inter-Item Covariance	0.12	-0.392	0.397	0.789	-1.014	0.024
Inter-Item Covariance	0.014	-.401	0.626	1.027	-1.562	0.039

From the case processing summary of the SPSS analysis of the Friedman test in Table 5.2, the asymptotic significance value ($p = 0.001 < 0.05$) indicates that there is a highly significant statistical difference in the question items, and the null hypothesis should be rejected.

5.8.2. Existing New Zealand building act needs amendment

The survey participants were asked, in their opinion, the extent to which they agreed that the existing building act needs Amendment. In total, approximately 45 per cent of the respondent agreed that the existing building act needs Amendment, with only 0.9 per cent that strongly disagreed, as illustrated in Figure 5.2.

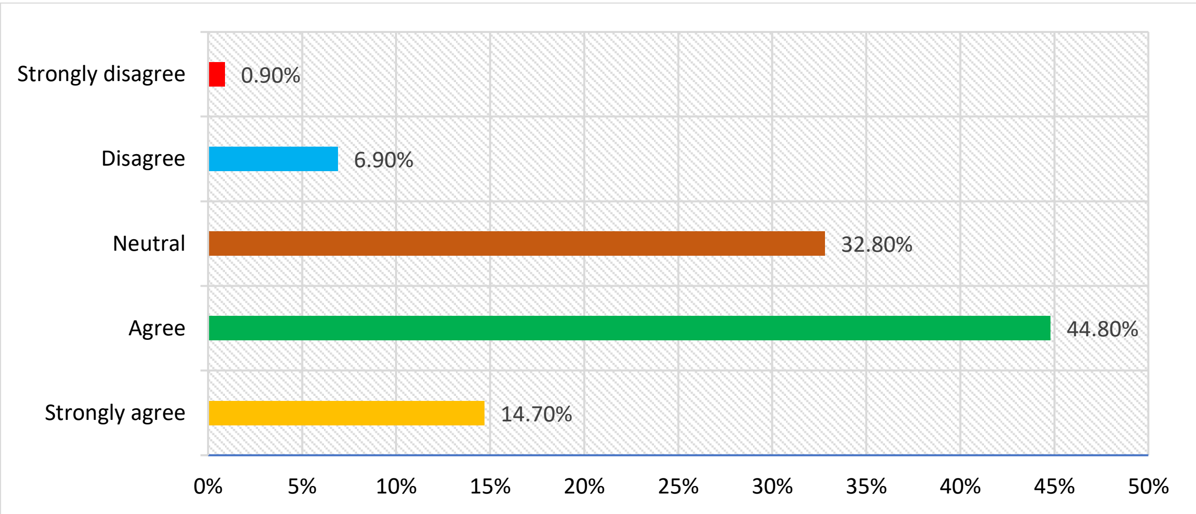


Figure 5.2: The need for existing New Zealand building code amendment.

Figure 5.2 shows that updating the building act is an essential approach welcomed by the majority of the building code users. Although, 32.8 per cent of the respondents were neutral, while 6.9 per cent disagreed on amending the existing building act. The high proportion of neutrality could imply that the undecided position is a result of the consistent Amendment to building code without any defined interval in the past. Updating the existing building act increases the ease of application and encourages compliance among the code users (MBIE, 2019h). Comparing the proportion of the respondents that agreed (44.8 per cent) with those that strongly disagreed (6.9 per cent) suggests that improving the existing building act in the country could reduce the impact of a disaster in the built environment with an emphasis on earthquake. Findings from this study based on the need for building act amendment could suggest that avoiding to amend building act means that natural hazards in the built environment have high tendencies of resulting in disaster. Bergeron (2008) opined that building occupants safety, health and economic loss reduction present the need for building code regulatory updates.

Creating awareness among the code users and the public could increase the understanding and the need for building code amendment. Ahmed et al. (2018) reported that the impact of earthquake in Nepal and Bangladesh raised the necessity for building code implementation and Amendment among the regulated, the regulator, the public and the government. Waiting for disaster occurrence as a reminder for building code amendment is costly (Nwadike et al., 2019d), as most building codes are developed after a disaster (Deepak Pant, 2015; Nwadike et al., 2019a). The Amendment cost, technical complexity and time have hindered building code amendments and maintenance in many countries (Listokin & Hattis, 2005).

5.8.3. New Zealand building code compliance documents need amendment

In response to the need for building code compliance document, 53.4 per cent of the surveyed participants agreed to the need for amending the compliance documents. Some of these respondents strongly agreed (13.8 per cent) that it is crucial to update the compliance documents, whereas 29.35 per cent decided to be neutral on the issue with only 0.9 per cent strongly disagreed and 3 per cent of the participants disagreed, as shown in Figure 5.3.

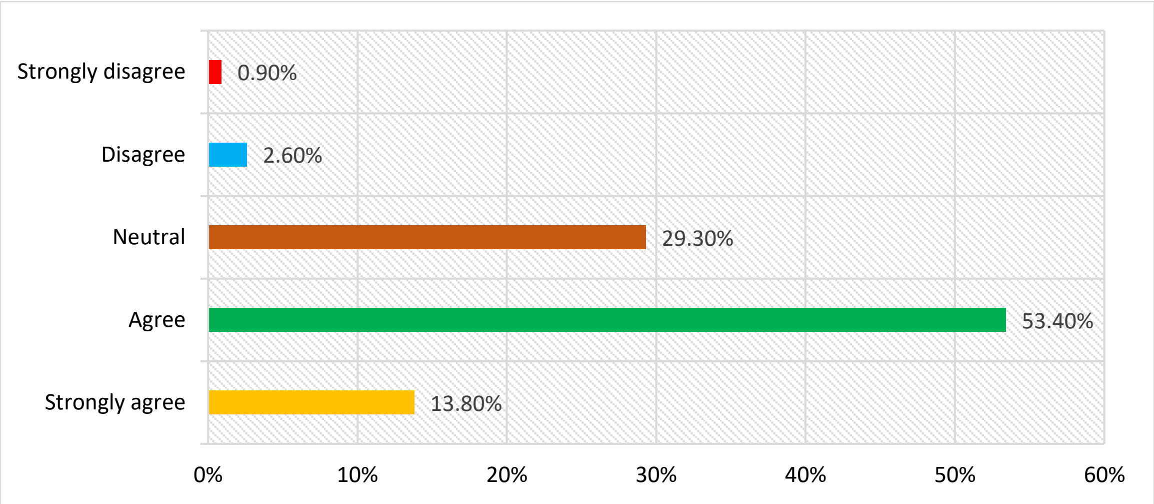


Figure 5.3: The need for building code compliance document amendment.

The high proportion of agreement indicates that the building code user agrees to the Amendment of building code compliance documents. Improving building code aims at increasing building resilience, providing building safety and simplifying the compliance pathway (MBIE, 2019c). The building code amendment process in New Zealand can be initiated by either a building owner, the local council or other agencies that are qualified to do so (MBIE, 2016g). Building code compliance documents in the country have passed through several amendments sequentially, without any stipulated period of the Amendment (Nwadike et al., 2019a). Notwithstanding, MBIE (2018b) announced a bi-annual amendment process of amending building code since 2018.

5.8.4. Free access to building code amendment documents in New Zealand

Following the building code amendments, the code users were questioned on their view in making building code, standards and other associated compliance documents free of charge to the public. About 43 per cent of the survey participants strongly agreed, while 38.8 per cent agreed that it should be free of charge to the public. However, only 1.7 per cent strongly disagree, and 0.8 per cent disagreed among the respondents that building code documents and standards should be made free of charge to the public. Moreover, 5.17 per cent of the respondents remained neutral on having free building code materials. Figure 5.4 shows the building code users opinion on free access to building code and the associated documents.

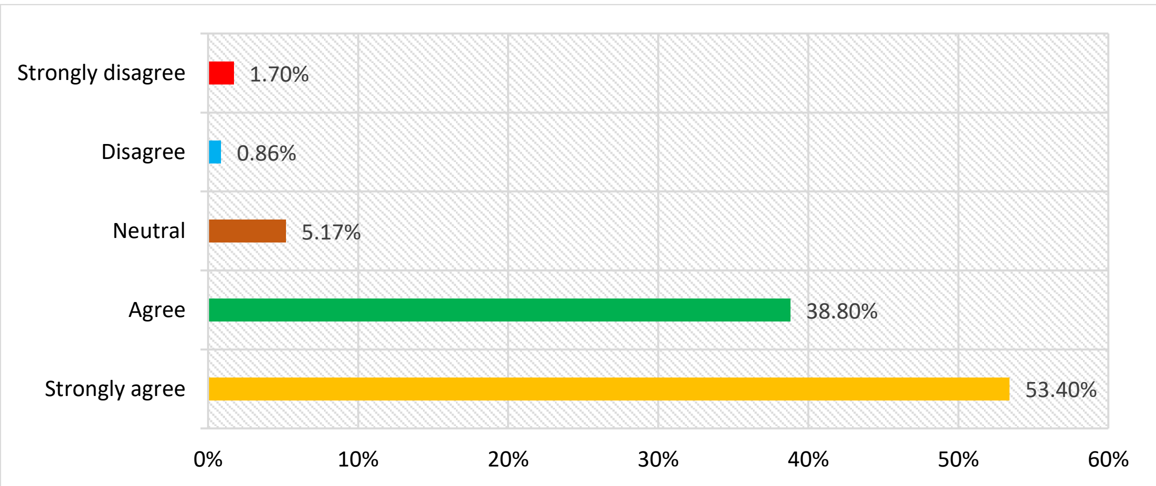


Figure 5.4: Free building code access in New Zealand.

The above responses regarding making building code free to the public show that free building code would increase the level of implementation and compliance. The cost of purchasing building code, standards and other related documents could stop the users from applying building code best practice (MBIE, 2019d). The findings in this study agree with the opinion of (Jenny Salesa, 2019) that free building standards initiatives eliminate compliance barriers.

5.8.5. Duration of building code amendment

To gain a deeper understanding regarding building code amendment in New Zealand, the study participants were questioned how often the building code should be amended on a five-point Likert scale. The responses of the survey participants are illustrated in Figure 5.5.

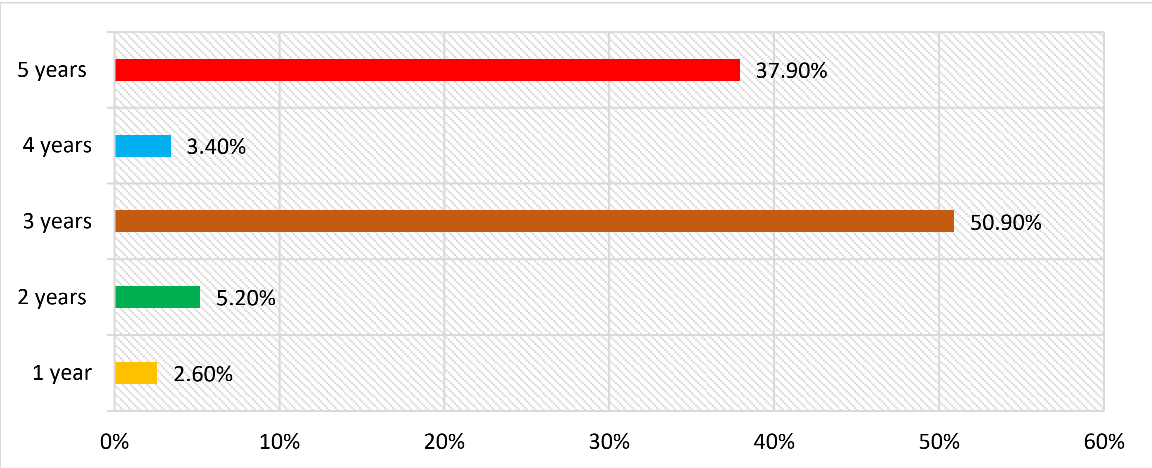


Figure 5.5: Building code amendment duration in New Zealand.

Accordingly, 50.9 per cent of the participants believed that three years cycle is the best amendment interval for the building code. Five years amendment period was, however, the opinion of 37.9 per cent of the total respondents, whereas only 3.4 per cent supported a four years amendment interval. Only 5.2 per cent held the view that two years is the appropriate amendment interval, whereas 2.6 per cent agreed for a yearly building code amendment. From the finding in this study, the high level of agreement for a three years amendment interval could suggest that the country building code users did not wholeheartedly welcome the bi-annual building code amendment as implemented by the Ministry of Business, Innovation and Employment. The study outcome is in line with the findings from Vaughan and Turner (2013), which affirms a three-year review based on an average business cycle is three years. Also, many building regulators, countries and organisation have adopted a three years cycle for their respective building code amendment (IBC, 2006; NCC, 2015a). On the other hand, a five-year amendment interval for building code have been widely accepted in Canada (IRC, 2010a), partially in Japan (Moullier & Krimgold, 2015), and other countries. Furthermore, Nwadike et al. (2019a) noted that understanding when to amend the building code is a challenging task that requires attention.

5.8.6. Preferable pathway for building code amendment

Findings from Figure 5.6 implies that a more significant percentage (76.72 per cent) of the survey participants believed that the building code amendment process should incorporate both knowledge gained from the previous disaster and intensive research in updating the building code.

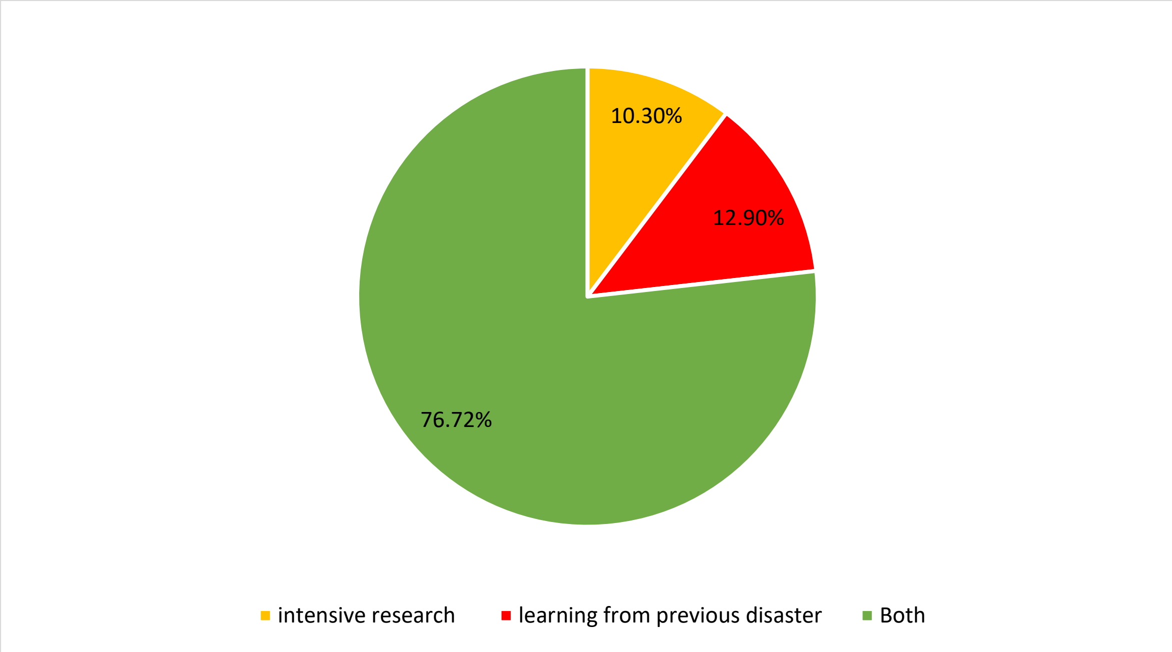


Figure 5.6: The preferable pathway for building code amendment in New Zealand.

The overwhelming support for the use of intensive research and learning from the previous disaster indicates that amending building code with these pathways reduces disaster risk impact and gives insight in developing a simplified building regulatory system that is context-specific. Furthermore, the outcome of the study shows that 12.9 per cent of the survey participants support the use of experience acquired from the previous disaster only while only 10.3 per cent holds the belief that intensive research is enough in amending building code. However, Spence and Kultermann (2016) noted the importance of intensive research in developing and establishing an efficient building code system such as the International Building Code (IBC), which has gained much attention in the United States and other countries. MBIE (2017d) reported the advantages of using knowledge learned from previous disasters such as earthquake, experience from other countries, and (BRANZ, 2014) innovative research in updating their code. Hence, the findings of this study conclude that the combination of knowledge gained from past disasters and systematic research are essential in establishing the safety of people and the country-built environment. Furthermore, creating an open, fair and transparent public opinion platform would promote a balanced contribution from all sectors and support the use of previous disaster experience, intensive research and industrial experience in updating building code.

5.8.7. Getting information from New Zealand building code updates

Amending building code and activating the implementation process requires a proper channel of communication that can able to engage the building code users. Five channels of disseminating information regarding new building code updates were identified and outlined in the questionnaire administered to the survey respondents. A more significant percentage (46.6 per cent) of the respondents identified that they get more information on new code updates through email, while 13.8 per cent affirmed that their colleagues and friends give them information regarding any amendment to the building code, as illustrated in Figure 5.7.

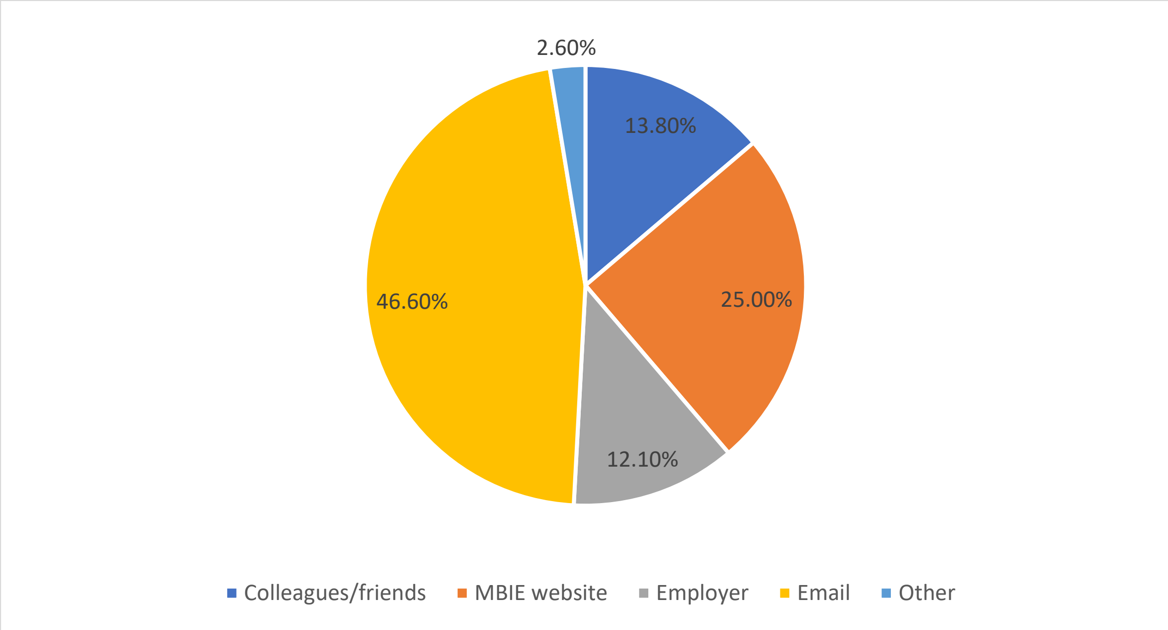


Figure 5.7: Getting building code updates in New Zealand.

According to 25 per cent of the survey participants, they regularly visit the MBIE website in search of any updates, compared to 12.1 per cent that wholly relies on their respective employers to get any update. Additionally, 2.6 per cent get their information through various means such as MBIE meetings, Engineering New Zealand monthly meetings, Engineering New Zealand websites, and Building Research Association of New Zealand (BRANZ) website. The above findings suggest that the use of email address in sharing building code amendment updates is an active channel among building code users in the country. A significant factor that will encourage the use of email as a more accessible platform for circulating information's relating to building code amendment is the subscription to the MBIE mail list. However, the proportion (12.1 per cent) that depends on the employers for building code updates could suggest that employees need motivation and encouragement to source information relating to building code. Ahmed et al.

(2018) and IRC (2010a) called for the development of an international platform where building code updates information can be disseminated and gained knowledge shared. On the other hand, publishing and distributing information's relating to code updates may incur a cost (David Kelly, 2012), which is necessary to achieve the purpose of amending building code.

5.8.8. Visitor counts to MBIE website in search of building code updates

The difference in the survey respondent opinions when asked how often they visit the MBIE website in search of information widens between the participants that visit the MBIE website always (2.6 per cent) and those that rarely (38.8 per cent) visit the website, as shown in Figure 5.8.

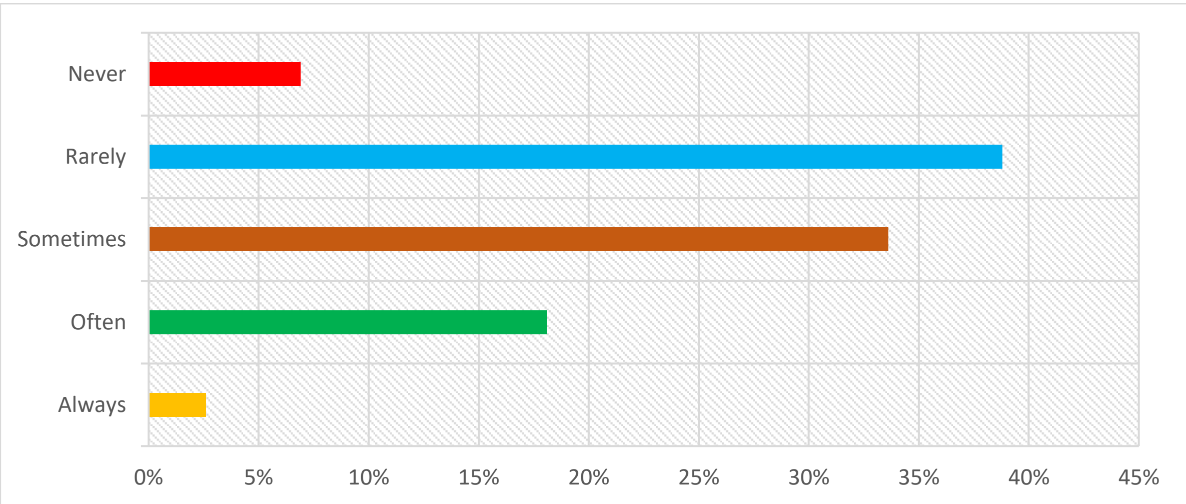


Figure 5.8: Building code users visit to MBIE website in search of building code update.

The results in Figure 5,8 demonstrates that building code users should be motivated to make a regular visit to the website. On the flipside, some of the questionnaire participants acknowledged that they never (6.9 per cent) visited the

MBIE website in search of information's regarding building code updates. Accordingly, 33.6 per cent of the respondents agreed that they sometimes visit the MBIE website, whereas only 18.1 per cent often surf the website. The MBIE is strongly committed to increasing compliance, more accessible to building regulatory documents (MBIE, 2019h) and ensuring safer homes through creating more online presence and launching new building system search engines called Building CodeHub (Build Waikato, 2019). Developing a smart app that can notify the building code users of any update from the code regulators could go a long way in creating awareness on building code amendment.

5.8.9. Building code amendment following any significant disaster

Regarding whether the New Zealand building code amendment following any major disaster, 69 per cent of the survey respondents believed in amending the building code following any major disaster, as shown in Figure 5.9.

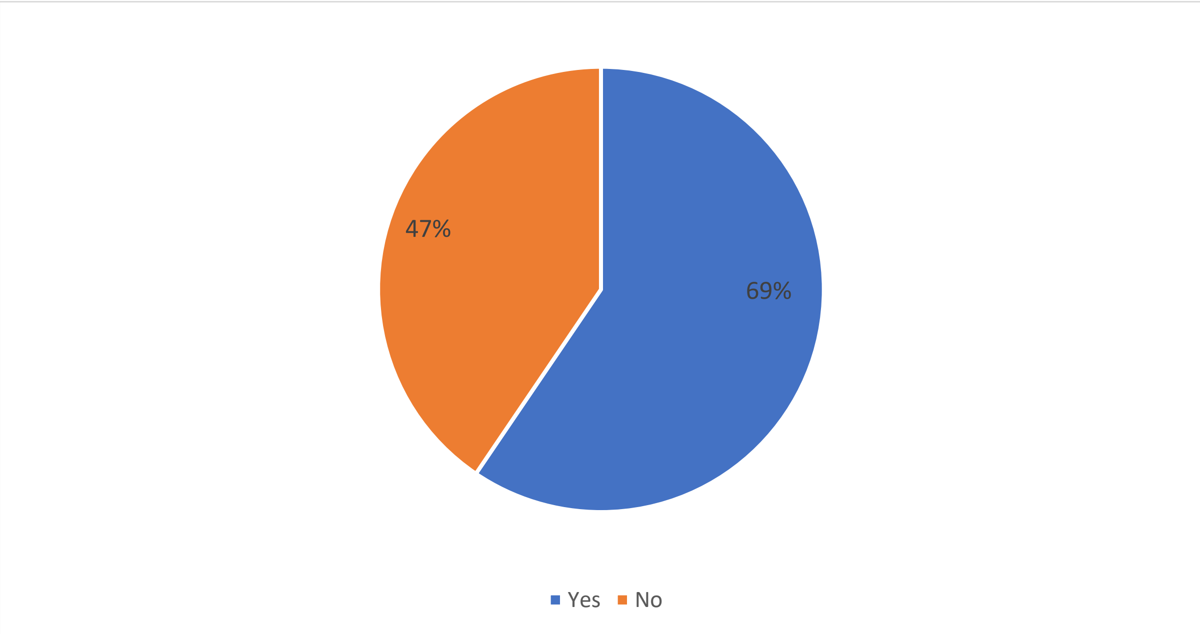


Figure 5.9: Building code amendment following any major disaster.

Conversely, 47 per cent are of the view that building code should not be amended after every major disaster. Figure 5.9 could indicate that the 2011 Christchurch earthquake and the 2016 Kaikoura earthquake changed how people perceive safety and building resilience, hence the quest for building code amendment following any major disaster in New Zealand. Mitigating the effects of the future disaster in the built environment may require a regular building code update to accommodate lessons learned from the previous disaster. Preparing for the next natural hazard demands a better review of the building regulations both to the new and existing buildings (Wilkinson Bryce, Crampton Eric, Jason Krupp, & Lianne Dalziel, 2018).

The outcome of this study aligned with the current practice in Japan (Jerry Velasquez, 2016; Maki & Hayashi, 2000) regarding building code amendment after a disaster. Kenji Okazaki (2008) noted that the Japan building code amendment has always aimed to correct some deficiencies in the building code following knowledge gained from the previous disaster, such as an earthquake. Moullier Thomas and Keiko Sakoda (2018) highlighted the benefits of amending building code in response to continual disaster occurrence and socioeconomic changes in the built environment.

5.9. Conclusion

This study investigates the opinion of building code users relating to the need for amending existing building act and codes, improving access to revised documents, scheduled amendment intervals, amendment methods, and the significance of making building code, standards and other related materials free of charge to users. Empirical data was used to examine how the application of building code could be improved through the user's opinion. The majority of the questionnaire participants agreed that the existing building act, codes, and building standards need an amendment to continue providing safety while reducing property losses. While amending building code is essential, the amendment interval should be designed to allow the building code users to implement and comply with the previous changes rather than running to catch up with the continuous Amendment. The frequent Amendment without a well-calculated interval could result in non-compliance. Hence, this study recommends a three-year cycle amendment interval in New Zealand, as this is practised in some countries such as Australia (David Wheeldon, 2014) and most states in the USA (Brad Kelechava, 2017). Making the amended building codes and standards free of charge to users would encourage a high level of compliance requirements.

Furthermore, the building code regulators should utilize various means of communication with an emphasis on using email in reaching out to the code users. Also, the code users should be encouraged to visit the MBIE website to seek information relating to building regulations. Moreover, as the natural hazard is dynamic and understanding increase over time, building code amendment should be based on intensive research, industry experience and the knowledge gained from the previous disaster.

However, cost and Copywrite regulations could be challenging in making building code available for free. Also, the quest to ensure the continuous safety of the citizens and achieve a resilient built environment could make it difficult for MBIE to wait for three years cycle before amending the building code. This is true since New Zealand is geographically prone to various forms of natural hazards such as an earthquake. Regular training of the building code users on how to comply with the building, offering incentives and promoting the need for a frequent visit to the MBIE website would go a long way in improving the understanding of the code users.

The research findings in this study are aimed to inform and guide the building policy regulators in making decisions that can create an enabling environment for the code users. An adequate environment for the code users improves disaster resilience in the built environment through proper application and implementation of code requirements in design and construction. Further research should consider addressing how the three years amendment cycle could be implemented in New Zealand with an adequate training package for the code users. Also, how to make all building standards free of charge could be explored. Acting on the findings in this study would motivate the participation of building code users in the building code amendment process and encourage easier compliance. The study acknowledged limitation in the research findings as the demographic sample could be biased towards structural engineers when compared with other participants. Hence, further studies are recommended to balance the demographic sample of questionnaire survey participants.

6. Why amending building codes? An investigation of the benefits of regular building code amendment in New Zealand

This chapter was developed from Publication № 5, which has been published in the International Journal of Building Pathology and Adaptation.

DOI: https://doi.org/10.1108/IJBPA-08-2020-0068. This chapter aims to answer the research question RQ3 and research objective RO5.

Abstract

The New Zealand building code has played a vital role in reducing the impact of disasters in the built environment. Following the nature of earthquake occurrences, the associated impacts such as building collapse, and the increase in technological innovation in the building sector, the New Zealand building code has been frequently amended. The building code amendment ensures that buildings and other related infrastructures can withstand the impact of ground shaking without substantial damages to buildings. The purpose of this paper is to identify and explore the benefits of building code amendments in New Zealand. Document analysis and a closed-ended questionnaire were adopted as data collection instruments for this study. The relevant stakeholders comprise of structural engineers, geotechnical engineers, architects, building services consulting engineers, licenced building practitioners, project managers, building contractors,

representatives of local authorities, academic/researchers, and quantity surveyors. A significant proportion of the survey participants that agreed to the importance of building code amendments in New Zealand justifies the benefits of the amendments. The study serves as a useful guide to policy regulators and researchers who are exploring other aspects of regular building code amendments in New Zealand. The findings from this study suggest that amending the New Zealand building code needs a proactive approach to promote local technology, enhance low-cost construction materials, training of code users and reducing bureaucracy in design approval and construction inspection. The study concludes that improving on the 28 factors identified in this study would contribute intensively to disaster risk reduction in the built environment and an increase in compliance level in New Zealand.

6.1. Introduction

The impact of disaster echoes the significance of building code in providing safety to building occupants and the entire built environment. The building code is a measure to reduce disaster impacts and improve the built environment resilience (Burby & May, 1999; Nwadike, Wilkinson, & Clifton, 2019b). Earthquake and other forms of natural hazards impact could be reduced by practical implementation, enforcement and compliance with building regulatory requirements stipulated in the building code. The limited damage losses recorded in the 2010 Darfield earthquake (Gledhill, Ristau, Reyners, Fry, & Holden, 2010; GNS, 2010), 1994 Northridge earthquake (Petak & Elahi, 2000), Japan earthquakes (Maki & Hayashi, 2000) and some other forms of disaster in the

United States (Burby & May, 1999) are attributed to adherence to the requirements of building code. In contrast, the losses from the Gujarat earthquake (Jones & Vasvani, 2017a; Mistry, Dong, & Shah, 2001), 2015 Nepal earthquake (Goda et al., 2015), Hurricane Andrew (Glenn, 2017) were all connected to negligence and non-adherence to building code requirements. Spence (2004) reported low damage resulting from building code compliance and implementation in countries where building code is practically followed and the compliance level is high. However, the large scale damage from the 1999 Kocaeli earthquake in Turkey was due to the deficiency in building code requirements (D'Ayala, 2003; Johnson et al., 2000). This indicates that enacting building code practice does not reduce the disaster impact, but compliance with the building code regulation minimises disaster impact (Nwadike et al., 2019d).

The occurrence nature of both natural and human-made hazards have suggested in strong terms the necessity of building code amendment on a regular interval. Nwadike et al. (2019b) noted that amending building codes should be an integral scheme in pre-disaster planning rather than a post-disaster scheme. Many developed and developing countries have adopted the culture of regular building code update within a specified interval. Amending building code is a driver towards increasing the resilience level of the built environment, provided it is backed with compliance, implementation and enforcement. The amendments allow for correction, creates a pathway for new concepts from either research findings or knowledge gained from previous experience (NCBCS, 2018a), and provides a platform for building code simplification with an emphasis on technical requirements. The benefits of building code amendment largely depend on the location, the process of amendment, code simplification, compliance culture and enforcement strategies (Nwadike et al., 2019b).

New Zealand is located in an active seismic environment that is prone to earthquakes and other forms of natural hazards. The country has experienced devastating earthquakes over the years and has positively proved to some extent to cope with the seismic disaster impacts. However, the 2011 Christchurch earthquake and the 2016 Kaikoura earthquake shows that the New Zealand building code needs improvement to reduce the disaster impact. This has triggered several amendments to ensure structural resilience within New Zealand built environment. Amendment to New Zealand building code has presented several unique opportunities that have enhanced and promoted the primary aim of building code in providing safety for the building occupants and the built environment before, during, and after any ground shaking and other related extreme loading conditions. Therefore, there is a need to examine the benefits of building code amendment as a vital tool for disaster risk reduction in New Zealand.

Within the above context, this study focuses on identifying and exploring the benefits of building code amendments in New Zealand and recommends the best ways these identified factors could be improved to encourage compliance culture with building code requirements towards reducing the natural hazard impacts. The purpose of the study was achieved through a mixed method of data collection. A questionnaire survey was conducted with relevant stakeholders to explore their individual opinions on the benefits of building code amendment. At the same time, document analysis (Bowen, 2009) was conducted through data extraction from the

MBIE website to assess the amendment records and observe the regularity of building code amendments in New Zealand from the onset. The findings from this study offer opportunities for building code regulators and users towards improving the building code compliance culture and promote a resilient built environment in New Zealand.

6.1.1. Research objectives

The overarching aim of this study was achieved through the following objectives:

i) To identify and explore the significance and benefits of building code amendments in New Zealand

ii) To provide recommendations on what best measures would improve the positive impacts of building code amendment in New Zealand.

6.2. Literature review

This section gives an insight into the review of existing contextual and relevant literature on the historical advantages, reasons and evaluation of New Zealand building code amendments.

6.2.1. Building code and its benefits

Building code is among the significant tools of disaster risk reduction in the built environment field. It clearly states the building performance expectations during and after any ground shaking or other extreme loading conditions to protect the occupants from injury or death (Ahmed et al., 2018; Mohamed, Edwards, Mateo-Garcia, Costin, & Thwala, 2019). In some other cases, the building code describes the systematic procedure of how to achieve its primary purpose. The building code ensures the minimum life health, safety, and the way design and construction should be carried out (MBIE, 2014b). Accordingly, building code is a strategic tool that assists the government, regulators and the regulated to reduce disaster impact and truncate natural hazards from turning into a disaster.

Even though building code provides the minimum standard for building construction, Khan, Uneb, and Fawwad (2010) argue that it restrains the saving techniques for the choice of cost and construction methods, which technically limits the progress of the construction industry. Moullier and Krimgold (2015) established that there are some factors that limit the effectiveness of building code in reducing the impacts of a disaster. Building code regulation with skilled, trained and experienced professionals in the construction industry is more beneficial to strict building code enforcement (Carla, 2016; Scott, 2010). The building code minimum standard requirements stipulated in the codes should surpass the bare minimum requirement (Carla, 2016), which makes it necessary to have a regular code update. In many instances, the building code is too complex to use, partly as a result of multiple improvements (Heijden et al., 2007) and adapting foreign building codes without the necessary technical capabilities (Spence, 2004).

The efficacy of building code in reducing the impact of disaster triggered by natural hazards is evident in the human-built environment. The impact of two earthquakes with similar magnitude in the 2010 Darfield earthquake (GNS, 2010) and 1994 Northridge earthquake in Los Angeles (Petak & Elahi, 2000) were found to be negligible in terms of death rate and damage to property. The main reason for the negligible impacts was hinged on the strict building code implementation in those areas, compared to the impact of the 2010 Haiti earthquake (Lindell, 2010) that caused significant catastrophic damages to the country.

A similar magnitude of quake recorded only two deaths in Paso Robles 2003 earthquake in California, whereas and about 40,000 deaths were recorded in the 2003 Bam earthquake with widespread damages to properties (Gharaati & Davidson, 2008; Kenny, 2009). Building code amendments are advantageous towards saving construction costs and the introduction of up-to-date technology, which increases resilience and response (NCBCS, 2018a) to disaster impacts in the built environment. Accordingly, building code centred on performance-based has opened doors to explore the international market (Khan et al., 2010), and fostered collaboration between different countries and organisations. Well implemented building codes often contributes to minimising or eliminating the damage liability posed to building professionals and property owners in the event of a disaster (NCBCS, 2018a).

While most developed countries, such as the United Kingdom and the United States of America, established their building codes from scratch (Ahmed et al., 2018; Moullier & Krimgold, 2015). Other developing and underdeveloped nations have either adopted or modelled their building codes from the existing codes, and, in some cases, this is done with adequate technical competencies (Heijden et al., 2007). Some countries such as the USA use different building code according to their respective states, regions or provinces.

After drafting, developing and reviewing a building code and its associated documents (Ching & Winkel, 2018), it remains a draft until it is formally enacted into law by relevant government authorities or designated entities. It is only after the building code draft has been enacted into law that it becomes a legal document. Enacting building code into law is good, but without the corresponding components, the primary aim of building code may not be achieved. These corresponding components of the building code include effective implementation of the code requirements, enforcement, compliance, and regular building code amendment and the associated compliance documents (Nwadike & Wilkinson, 2020b). Building code outlines either the step by step procedures or the expected building performance during and after an earthquake.

According to USAID (2016), effective implementation of building code helps to minimise the risk of earthquake damages. Non-compliance and enforcement with building code have led to large-scale disaster loss of human and properties (Ahmed et al., 2018; Dixit & Esteban, 2009) and requires multi-sectional intervention (Jishnu, 2008). Kandel (2007) noted that enforcement of building code faces obstacles because of a lack of capacity and proper policies in Nepal.

Different professions widely use building code at different stages, time, and for various purposes. These professions include engineers, local authorities, contractors/builders, manufacturers, designers, and communities. Though the method of building code application differs from country to country, they all have one aim of providing the minimum standard for the health and safety of building occupants and the building. Different countries, however, have various pathways to achieve the minimum requirements of their respective building code. Effective building code provisions comprise four major components that should work together at different stages to ensure a safe human-built environment. The stages of building code include the development and enactment stage, the implementation stage, and the maintenance stage.

In stage one (i.e., the development and enactment stage), the building code is developed and enacted into law. This stage requires the consultation of relevant stakeholders and the legislation process and varies for different countries. The enactment of the building code into law gives the regulators and the government legal power to prosecute the offenders at any given time. Notwithstanding, in some countries, the building code is not a mandatory document (Krimgold, 2011; Spence, 2004). Stage two (i.e., the implementation stage) involves the requirements of the building code to be implemented according to design, enforcement and compliance. The enforcement at this stage of the building code requires the establishment of an enforcement team drawn from all angles (Dixit & Esteban, 2009) and the collaborative effort of all relevant stakeholders. This stage plays a vital role in determining how effective the requirements of the code on the paper document can be converted to practical design and construction towards reducing disaster impacts. Stage three (i.e., the maintenance stage) ensures regular updates of building code, either through experience gained from previous disasters, research, or both, to improve the building resilience of the built environment. Stage three also involves knowledge sharing and collaboration amongst different countries, organisation, and research institutions, at different levels. Both the implementation and maintenance stages often involve an intensive training programme for both the code users and its regulators.

In the context of disaster, synergising the three stages of the building code would enhance its application as an essential measure to reduce disaster impacts, improve resilience, and promote development after disasters. Nevertheless, while stage one and three are usually carried out at the national level in some cases, the local authorities often manage stage two. Although, it varies from country to country.

6.2.2. Evolution of New Zealand building code

Early New Zealand building bylaws were developed and managed by provincial councils across the country. However, the very first national building legislation is known as the 'Raupo House Ordinance' was established in 1842, which was drafted based on the effects of fire (Nigel, 2011). Some provincial councils (such as Auckland in 1854; New Plymouth in 1858; Otago in 1862; and Canterbury in 1867) later followed the Raupo Houses Ordinance to develop and manage their bylaws (Nigel, 2011). As time progresses, the New Zealand construction industry was using over 60 Building Acts in 19 central government departments and over 300 municipal authorities from 1979 till when the first building code was relatively derived from the Norwegian building code in 1991 (Nikki, 2014). The unified national building code had three clauses of general provisions and 38 clauses that addressed building performance criteria and applied to all forms of construction, including new and existing buildings, alternations, renovations, and demolitions (MBIE, 2014b).

6.2.3. The purpose of building code

The primary purpose of the New Zealand building code (NZBC) is to protect public health and provide safety by regulating and setting out the minimum requirements for building and other related structures. The New Zealand performance-based building code has three building control framework, namely: (1) the building act which regulates all building works, (2) the building regulations describe the specified systems and sets the rate of fees, (3) the building code, which sets the performance standards for all building construction (MBIE, 2014b). The MBIE has the statutory responsibility to regulate all activities of the New Zealand building code with the help of other subordinate entities such as the territorial authorities, building consent authorities, regional authorities, building owners and licensed building practitioners (MBIE, 2014b). Furthermore, this made the NZBC a mandatory requirement for all building works. The Building Act 1991, section 229, allows the territorial/regional authorities to enforce the building code where infringement is noticed (MBIE, 2008).

6.2.4. Modern era

The quest to have a coherent and unified National building code triggered dissatisfaction and later led to the establishment of the Building Industry Commission (Nikki, 2014). The commission was tasked to find a legal building regulatory provision for building construction in New Zealand. The report of the commission paved the way for the Building Act 1991, which followed the Nordic model (Nikki, 2014) with different application methods. The New Zealand Building Act 1991 had an explicit performance that covers a range of technical provisions, which greatly differentiated it from the building codes used in other countries (Beller, 2001).

The building Act 1991, which empowered the local authorities to act and manage all building control functions, took effect in 1992 as the New Zealand performance-based building code (MBIE, 2014b). Following the enactment of the performance-based building code, the Building Industry Authority (BIA) was formed to function as the building code monitoring agency for the central government. According to Nikki (2014), the New Zealand building code only explains the functional requirements and performance criteria that all structures must satisfy during their intended use. The New Zealand building code ensures adequate balance on quality, affordability, cost, innovation and accessibility (MBIE, 2017b). New Zealand has strict laws regarding building code, which has been developed over the years, made evident in the 2010 Darfield earthquake in Canterbury (GNS, 2010).

The 1991 Building Act was repealed and replaced with the 2014 building Act (Nikki, 2014), which introduced some new controls such as consent authorities and licensed practitioners. The Building Act 2004 philosophy has stronger consumer protection control by placing much emphasis on building property owner's welfare and the occupants (Mumford, 2010). Whereas the Building Act 1991 primarily focused on encouraging innovation while the Building Act 2004 was a response against building failure resulting from innovation (Duncan, 2005; Mumford, 2010). The building industry Authority was later dissolved, and their functions transferred to the Development of Building and Housing following the building Act 2004 (MBIE, 2017b).

6.2.5. Reasons for building code changes

The "leaky buildings" saga in New Zealand triggered a call for the amendment of the Building Act 1991, which took effect in 2004 (James & Mike, 2012; Maurice, 2012). The reviewed Building Act 2004 activated detailed amendments to the New Zealand building code (Duncan, 2005). The amendment was an opportunity to align the building code with the changes made to the Building Act 1991. The Building Act 2004 amendment majorly focused on addressing amenity and sustainability level with extension to the establishment of consumer protection rights and builders license strategies (Duncan, 2005).

The Building Act 2004 tightened up the innovation scope widely embraced in the Building Act 1991 by tasking the designers and product manufacturers to demonstrate performance requirements to the building code (Mumford, 2010). The innovative system is mainly captured in the alternative solution in the New Zealand building code. The deficiency of a clear pathway for alternative solutions to become an acceptable solution was considered by the New Zealand experts as a potential barrier that could restrain the enhancement of alternative solutions (Bill, Simon, Steven, & Rodney, 2011). Following the performance of existing buildings during the 2011 Canterbury earthquake, the New Zealand Building Act 2004 was amended in 2016. The Building Amendment Act 2016 focused on managing earthquake-prone buildings, and it uses the knowledge gained from past earthquakes within and outside New Zealand (MBIE, 2017h).

Some importance of building code amendment has also been identified from existing literature. According to Vaughan and Turner (2013), disasters stirred by natural hazards are among the major factors that led to the strict modification of building code with reference to the aftermath of Hurricane Andrew in 1992. Lauren (2018) also believes that building code update balances the equation of extreme conditions in the built environment. Building code has played a primary role in reducing damage threat from natural hazards with an emphasis on saving the economic loss of property owners and taxpayers (Ahmed et al., 2018; Theckethil, 2006). Building code amendment has narrowed the gap of discrimination previously experienced by people with disability through provisions to allow for easy access pathway to public buildings (MBIE, 2005).

Though some advantages of building code amendments have been highlighted, Dixit and Esteban (2009) have noted that many building codes may be insufficient, outdated, too complicated, not user-friendly, ineffective, and non-flexible in implementation and addressing the disaster. Since the 1991 Building Act of New Zealand was established, the building code and the associated compliance documents have undergone several amendments consistently to guarantee improved building performance in any seismic condition, life safety and reduce complexity. Furthermore, it is obvious that having a building code is not good enough to reduce the impact of natural hazards, but regular amendments help to achieve the primary aim of building code (Nwadike et al., 2019b).

6.3. Research method

This section introduces the methods of data collection and analysis used for this study. In Consideration of the research objectives, this study used a closed-ended questionnaire and document analysis as a research method.

6.3.1. Data collection

The mixed-method approach was adopted for data collection. The primary reason for using a mixed-method style in this study is because data used for this study were collected from different sources, and it provides better philosophical assumptions that combine a qualitative and quantitative approach to enhance the study output (Creswell & Clark, 2017; Ivankova, 2014; Yin, 2006). The mixed-method research approach uses the potential strengths and weakness of both the quantitative and qualitative method of data collection to provide a deeper insightful explanation of a phenomenon (Greene et al., 1989; Lewis-Beck et al., 2003; Östlund et al., 2011).

Firstly, document analysis as a qualitative research technique was used to extract historical data from the Ministry of Business, Innovation and Employment (MBIE) website (MBIE, 2016j). New Zealand's building code amendment records from 1993 to 2019 were extracted. Document analysis allows for a systematic evaluation and interpretation of existing data to develop an empirical understanding within a context (Aigwi, Phipps, Ingham, & Filippova, 2019; Bowen, 2009; Corbin & Strauss, 2014; Rapley, 2008). In the context of this study, document analysis was used to gain knowledge of the existing building code amendment count in New Zealand.

Secondly, quantitative research was conducted using a closed-end questionnaire. The rationale behind the use of the questionnaire technique is because it is a cost-effective approach to gather a large amount of data, and the obtained data can be quantified (Bird, 2009; Bulmer, 2004; Krause, 2002; McGuirk & O'Neill, 2016). The questionnaire was administered to participants to obtain their opinions regarding the significance and benefits of New Zealand building code amendments and the associated compliance document amendments. The questionnaire consisted of eight sections relating to participant's profile information, the significance of building code amendment to resilience, enhanced training and skill transfer, technical improvement, quality of construction materials, organisational factors, compliance and enforcement, and innovation and technology.

A purposeful sampling technique was adopted in the selection of participants in this study based on their knowledge regarding the New Zealand building code. This method allows participants that have vast knowledge on the research focus to be selected (J. A. Maxwell, 2013). The participants were chosen across New Zealand comprising of structural engineers, geotechnical engineers, architects, building services consulting engineers, licensed building practitioners, project managers, building contractors, local authorities, researchers and quantity surveyors. The closed-ended questionnaires were distributed in person and through online surveys.

6.3.2. Data analysis

A total of 250 questionnaires were distributed physically to the selected participants. 33.2% of the administered questionnaire was completed and returned to the researcher. According to Onwuegbuzie and Collins (2007), a return rate above 82 participants is acceptable for correlation analysis. The Qualtrice survey software was also used for the online survey, which completely analysed 33 responses. The online survey was employed to bypass some limitations of distribution in person (Watt et al., 2002). Both the outcome of the physically distributed questionnaire and the online platform were combined for the analysis in this study. This gave a total of 116 completed and returned the questionnaire. All completed questionnaires were analysed using the IBM SPSS software.

6.3.3. Document analysis

Findings from the data extracted from the MBIE website shows that the New Zealand building code has undergone a series of amendments from 1993 to 2019. Figure 6.1 shows the number of building code amendments per year.

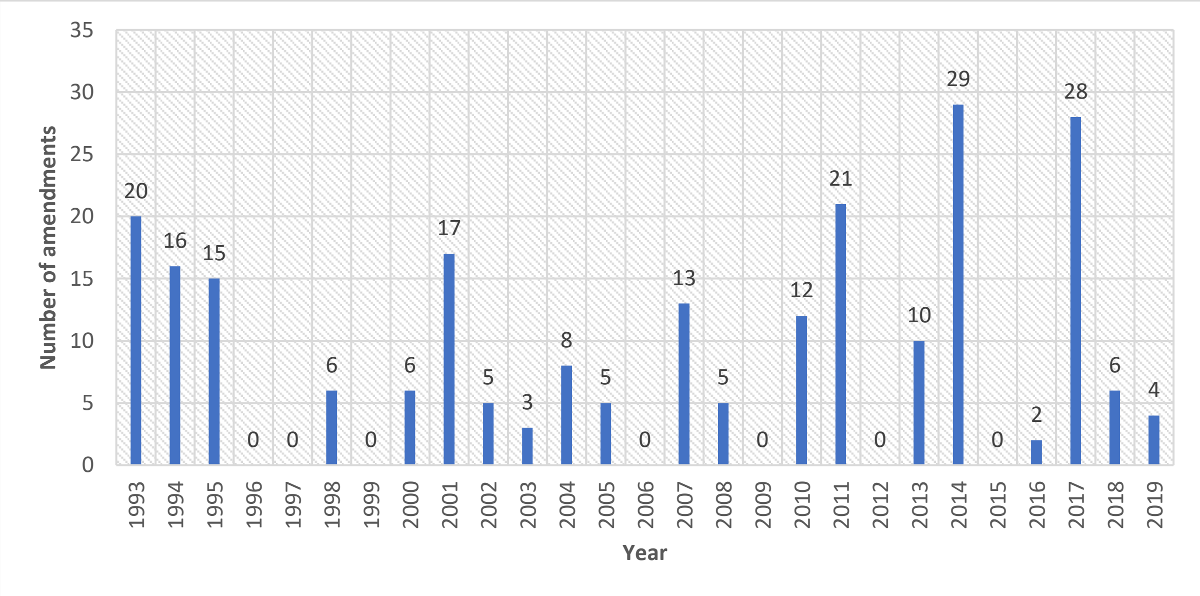


Figure 6.1: Amendment records to the New Zealand building code from 1993 to 2018.

As observed in Figure 6.1, the highest frequencies of amendments to the code were carried out in 2014 (29), 2017 (28), 2011 (21), and 1993 (20). The increase in amendment records in 2014 and 2017 was first, as a result of the response to the 189 recommendations of the Canterbury Earthquake Royal Commission (MBIE, 2017h) on the causes of building failure during the 2011 Christchurch earthquake. Secondly, the increase in the 2017 amendment count could be due to the 2016 Building Act amendment that centred on earthquake-prone buildings. Figure 6.2 illustrates the number of documents added to the New Zealand building code per year.

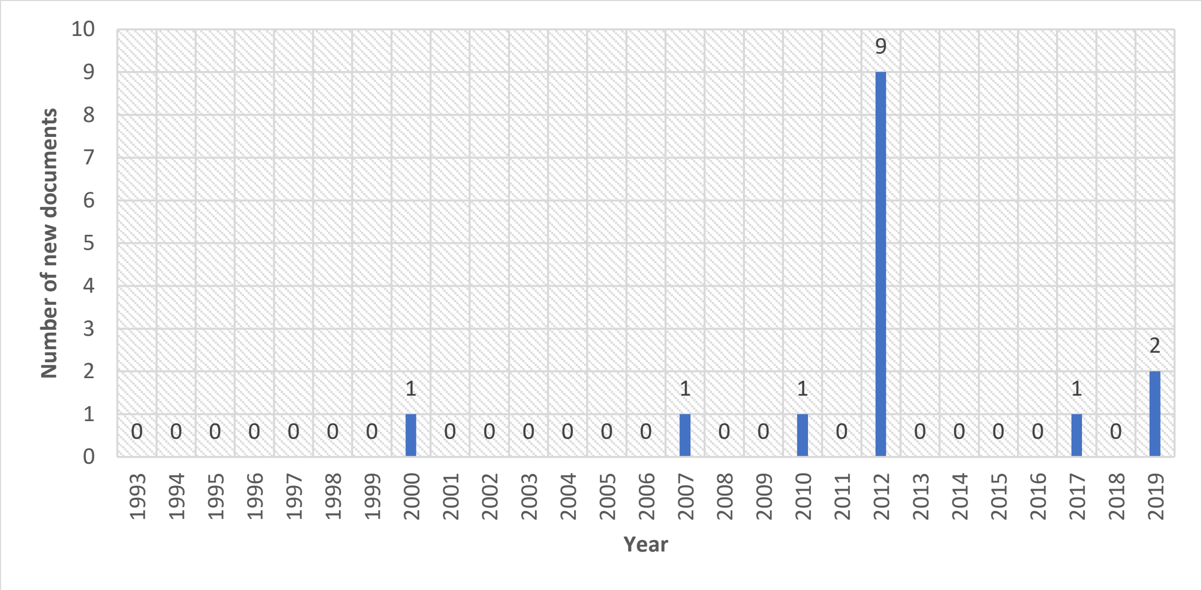


Figure 6.2: New documents added to the New Zealand building code from 1993 to 2018.

In 2019, six documents were discontinued from the building code relating to protection from fire. Furthermore, another four documents were discontinued in the building code fire safety section and one from protection from the fire section in 2000. New documents were introduced to the New Zealand building code in 2012 to ensure the code continues to protect the health and safety of the public. The nine documents added in 2012 could be in response to the 2011 Christchurch earthquake. Also, the new document added in 2017 could be a result of the 2016 Kaikoura earthquake and the Building Act amendment in 2016.

6.3.4. Participants profile

The participant's information obtained from the returned questionnaires is summarised in Table 6.1.

Table 6.1: Participants profile.

Category	Frequency	Per cent

Participants professional group		
Structural engineers	58	50
Geotechnical engineers	11	9.5
Architects	2	1.7
Consulting engineers	2	1.7
Licensed building practitioners	7	6.0
Project manager	15	12.9
Building contractors	4	3.4
Local authority	9	7.8
Academic/Researchers	8	6.9
Total	116	100
Years of professional experience		
0-5	23	19.8
6-10	34	29.3
11-15	23	19.8
16-20	17	14.7
>20	19	16.4
Total	116	100
Organisational size		
Large scale	50	43.1
Medium scale	44	37.9
Small scale	22	19
Total	116	100
Participants organisational position		
Director	24	20.7
Senior management	15	12.9
Middle management	20	17.2
Supervisor	17	14.7
Staff	40	34.5
Total	116	100
Participants location		
Auckland	45	38.8
Wellington	26	22.4
Christchurch	38	32.8

Dunedin	2	1.7
Others	5	4.3
Total	116	100

The participant's mix included structural engineers (50%), Project managers (12.9%), Geotechnical engineers (9.5%), Local authority (7.8%), Academic/Researchers (6.95%), Licenced building practitioners (6.0%), Building contractors (3.4%), Architects (1.7%) and Consulting engineers (1.7%).

The knowledge of the participants regarding their level of familiarity with the New Zealand building code was assessed. Table 6.2 helps to understand the participant’s familiarity with the New Zealand building code.

Table 6.2: Participants knowledge of New Zealand building code.

Level of familiarity with New Zealand building code	Frequency	Per cent
Very low	5	4.3
Low	19	16.4
Medium	37	31.9
High	40	34.5
Very high	15	12.9
Total	116	100

Some of the participants had a very high familiarity level with the New Zealand building code (12.9%), high (34.5%), medium (31.9%), low (16.4) and only 4.3% have a very low level of application of the New Zealand building code. The participant's profile shows that the questionnaire respondents have reasonable professional experience in the use of building code.

6.3.5. Questionnaire analysis

The IBM Statistical Package for the Social Sciences (SPSS) software was used to analyse the responses of the questionnaire survey participants. The participant's response was collected and entered into the SPSS software manually in a number-coded format for easy analysis and elimination of any possible oversight error. A spreadsheet of the participant's responses was tabulated in the excel sheet. Each questionnaire was assigned to a heading. This makes it possible to capture the opinion of each participant correctly. The Friedman test (Friedman, 1937) was used to measure the significant differences between each questionnaire item and their varied impacts in measuring the benefits of building code amendment in the New Zealand context. Furthermore, Cronbach's alpha (Tavakol & Dennick, 2011) reliability tool was employed to check the internal consistency of each completed questionnaire item in SPSS software.

6.3.6. Friedman test analysis

For this study, a non-parametric statistical test (Friedman test) was used to assess the significance and benefits of building code amendments in post-disaster reconstruction in New Zealand. The test tool was used as the benefits of building code amendment was repeatedly measured across various identified factors. The Friedman test was adopted to evaluate the advantages of the study focus by ranking all the factors according to each participant's view. In the analysis, different factors of measurement were placed on the columns while the individual participant's opinion is contained in the row form. The null hypothesis for this study is that there is no significant difference in each identified questionnaire item under the various categories of the benefits of building code amendment. Furthermore, if the significant value *(p)* is < 0.05, the null hypothesis is rejected based on the decision rule.

6.3.7. Questionnaire survey reliability check

The reliability test was employed to check the extent to which the study assessment tool measures the consistency of the obtained results. The inter-rater reliability test helps to interpret the various view of the participants in the study. The Cronbach's alpha test (Tavakol & Dennick, 2011) was used in this study to evaluate the internal consistency and reliability of the five Likert scale questions used to assess the impacts of building code amendment in post-disaster reconstruction in New Zealand.

To achieve the purpose of the reliability check in this study, the Cronbach's alpha coefficient was established as follows:

$$\alpha = \frac{N.\bar{C}}{\bar{V} + (N-1).\bar{C}} \tag{1}$$

Where N is the number of questions used in the questionnaire, $\bar{c}$ is the average covariance between the questions and $\bar{v}$ is the average variance.

The Cronbach's alpha with the range of $\alpha \geq$ 0.9 is considered excellent, while 0.5> α is unacceptable. The data analysis from the SPSS shows that Cronbach's alpha coefficient for this study is 0.945>0.7. This demonstrates an excellent measure of the internal consistency of all the identified factors in the designed questionnaire, as indicated in Tables 6.3 – 6.5.

Table 6.3: Reliability check.

Reliability statistics		
Reliability test tool		
Cronbach's alpha	Cronbach's Alpha based on standardised items	Total no. of questions
0.945	0.945	28

Table 6.4: Case-processing summary.

Number of participants			%
Cases	Valid	116	100.0
	Excluded[a]	0	0.0
	Total	116	100.0

Table 6.5: Summary question statistics.

	Mean	Minimum	Maximum	Range	Maximum/ Minimum	Variance	No. of questions
Item Means	3.665	3.284	4.009	0.724	1.220	0.035	28
Item Variance	0.903	0.534	1.555	1.021	2.910	0.053	28

6.4. Findings and discussions

The findings from the questionnaire survey measured the significance and benefits of amending building code in New Zealand. The opinion of the survey respondents was weighed using a five-point Likert scale. The five Likert scales comprised of five measurement criteria (i.e., strongly disagree, disagree, neutral, agree and strongly agree) options, which used to weigh the significance of each identified factor within the range of strongly disagree as 1 and strongly agree as 5 in the questionnaire. The findings of this study analysed in SPSS are discussed in the following subsections.

6.4.1. Significance of building code amendment to resilience

The participants were questioned regarding the significance of building code amendments towards attaining resilience. 72.4 per cent of the survey respondents strongly agreed that building code amendment had improved structural resilience. About 70 per cent, to a large extent, believed that resilience in New Zealand built environment has significantly improved. Accordingly, 57.8 per cent strongly agreed that improved resilience had encouraged pre-disaster policy implementation. The pre-disaster policy helps to increase resilience (Wasley, 2014). The improved resilience may be because of consistent changes made to the New Zealand building code.

The findings from this study are not surprising, as it aligns with the previous studies by Maki and Hayashi (2000) regarding improved building resilience in Japan. Building regulation is a significant measure that improves resilience in the built environment (Burby & May, 1999). Building code has increased resilience by reducing the impact of natural hazards (GNS, 2010; Petak & Elahi, 2000), as a result of strict building code implementation and enforcement (Jonathan, 2018). Ahmed et al. (2018) noted that adherence to building code requirements ensures building resilience. Findings from the Friedman test ($p = 0.03 < 0.05$) shows that the null hypothesis should be accepted. Figure 6.3 shows the significants of building code amendments to resilience. Table 6.6, 6.7, and 6.8 illustrates the summary of the mean rank, the Friedman test statistics and descriptive statistics, respectively.

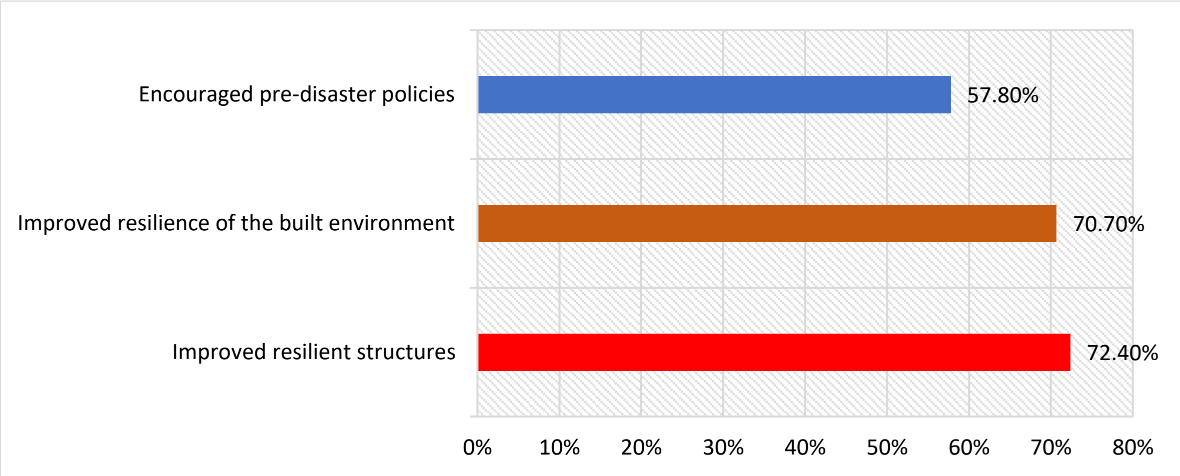


Figure 6.3: Significance of building code amendment to resilience.

Table 6.6: Friedman mean rank.

	Mean rank
Improved resilient structures	2.07
Improved resilience of the built environment	2.07
Encourage pre-disaster policies	1.86

Table 6.7: Friedman's test statistics.

N	116
Chi-Square	7.013
df	2
Asymptotic significance	0.030

Table 6.8: Descriptive statistics.

Item	N	Mean	Standard deviation	Minimum	Maximium
Improved resilient structures	116	4.55	0.878	1	5
Improved resilience of the built environment	116	4.26	1.080	1	5
Encourage pre-disaster policies	116	4.54	0.859	1	5

6.4.2. Enhanced training and skill transfer through building code amendment

The survey participants were asked the extent to which New Zealand's building code amendments have enhanced the training of the code users. This question was asked because training following changes to building code helps to understand the requirements of the code and method of implementation. The analysis from the questionnaire shows that 65.5 per cent of the respondents agreed that non-professional skills have increased following a series of building code amendments. Also, a total of 59.5 per cent agreed that professional skills have increased due to consistent code updates. While 62.9 per cent believed that the code revision had improved the training of the code user. This could imply that building code amendments in New Zealand is always followed by educating the building code users. Considering awareness, 62.9% per cent strongly agreed that reviewing building code helps to create awareness. Averagely, less than 50 per cent of the respondents believed that educating property owners increases their willingness to ensure that their buildings comply with the requirements of the building code.

The above findings on the impact of building code amendment on the training and skills transfer are in line with the findings from a similar study done by (Builderscrack, 2014). Furthermore, introducing changes to the building and the associated compliance documents creates an avenue for training code users on the best ways of fulfilling the purpose of the amendment (NCBCS, 2018a). However, previous studies reported that changes to the New Zealand building code were not followed with adequate systematic training of the code users (Duncan, 2005). This could imply that the building code end users are not satisfied with the level of training offered compared to the frequency of code changes in New Zealand. APN (2017a) has also noted that awareness is all stakeholder's function and can be implemented through partnership at all levels. This study, therefore, suggests that raising awareness of new changes to the building code is a motivating factor to the building code users, and it may increase the willingness of property owners to comply with the building regulations. The study also attributed the increase in both professional and non-professional skills to building code amendments, therefore acknowledging the efforts of the building code regulators in ensuring best competency in the construction industry (MBIE, 2019d).

The aggregate mean value (M = 3.142, SD. = 0.818) indicated that the New Zealand building code amendment could play a vital role in enhancing training and skill transfer. The findings from the Friedman test ($p = 0.001 < 0.05$) indicates that the null hypothesis should be retained. Figure 6.4 and Tables 6.9 to 6.11 shows a summary of these findings.

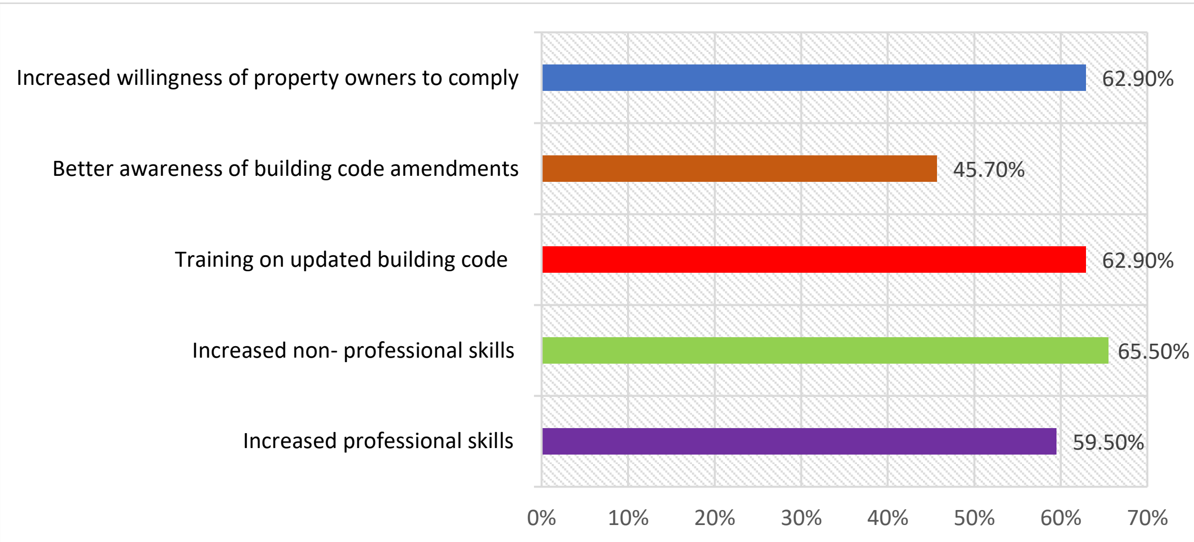


Figure 6.4: Enhanced training and skill transfer based on building code amendments.

Table 6.9: Friedman mean rank.

Mean rank	
Increased professional skills	2.78
Increased non- professional skills	3.67
Training on updated building code	2.83
Better awareness of building code amendments	2.88
Increased willingness of property owners to comply	2.84

Table 6.10: Friedman's test statistics[a].

N	116
Chi-Square	35.767
df	4
Asymptotic significance	0.001

Table 6.11: Descriptive statistics.

Item	N	Mean	Standard deviation	Minimum	Maximum
Increased professional skills	116	3.67	1.170	1	5
Increased non- professional skills	116	4.31	1.099	1	5
Training on updated building code	116	3.89	0.902	1	5
Better awareness of building code amendments	116	3.84	0.919	1	5
Increased willingness of property owners to comply	116	3.84	1.027	1	5

6.4.3. Technical improvement following building code amendment

In this section of the study, the respondents were asked to evaluate the level of technical improvement following building code updates. A total of 58.6 per cent of the survey respondents agreed that building code changes have increased transferability skills regarding new code requirements. Furthermore, 53.4 per cent of the respondents agreed to the increase in the competency level of the building code users in New Zealand. Also, 49.1 per cent agreed that technical assistance received from the code regulators and other agencies have improved following regular revision of the building code.

From the outcome on the impact of building code amendment on technical improvement, the high aggregate mean value (M = 3.74) and standard deviation value (SD = 0.99) implies that there are positive impacts of building code amendments on technical improvement on the part of the code users. The study suggests that the improvement in the competency level among the code users is a result of the strategic plans of the code regulators (MBIE, 2019d). Burby, May, et al. (1998) pointed out that providing adequate technical assistance to building code users helps to improve their competency and increase compliance with building regulations. The findings from the Friedman test ($p = 0.062 < 0.05$) indicate that the null hypothesis should be rejected. Figure 6.5 and Tables 6.12 to 6.14 depicts the summary of these findings from Friedman statistical test.

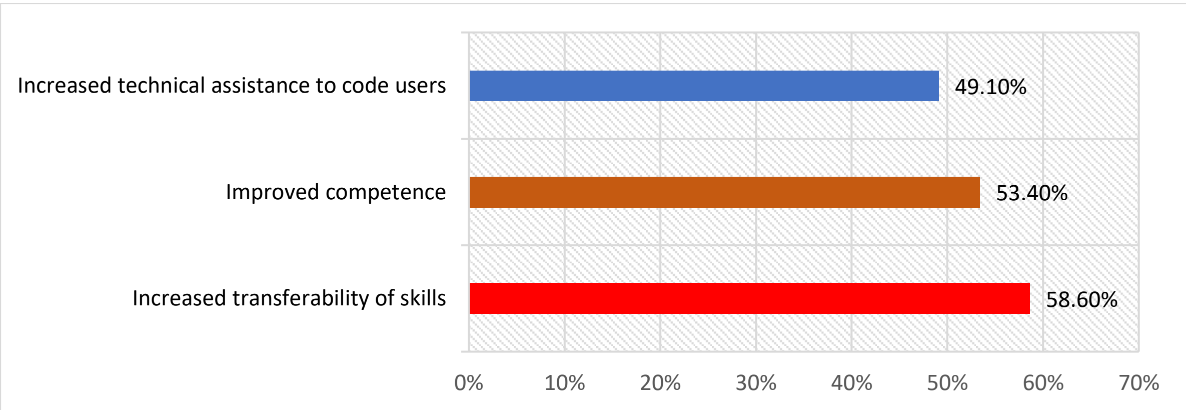


Figure 6.5: Technical improvement following building code amendment.

Table 6.12: Friedman mean rank.

	Mean rank
Increased technical assistance to code users	1.87
Improved competence	2.10
Increased transferability of skills	2.03

Table 6.13: Friedman's test statistics[a]

N	116
Chi-Square	5.565
df	2
Asymptotic significance	0.062

Table 6.14: Descriptive statistics.

Item	N	Mean	Standard deviation	Minimum	Maximum
Increased technical assistance to code users	116	3.61	0.967	1	5
Improved competence	116	3.83	0.963	1	5
Increased transferability of skills	116	3.77	1.033	1	5

6.4.4. Quality of construction materials on building code amendment

Figure 6.6 shows the respondents views on how building code changes impact the quality of construction material in New Zealand.

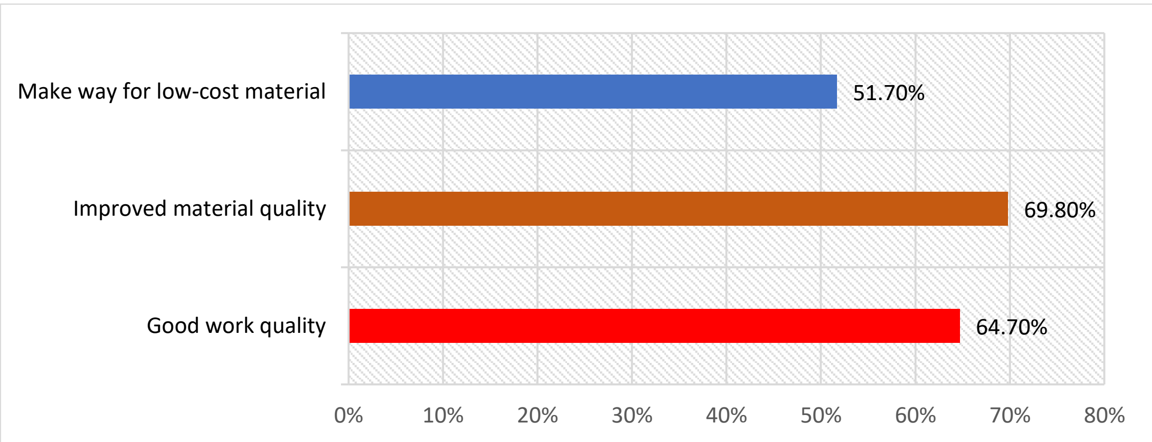


Figure 6.6: Quality of construction materials on building code amendment.

From Figure 6.6, the respondents (64.7 per cent) agreed that updating building code helped to increase the quality of construction work. The respondents strongly agreed that the quality of materials used in building construction has improved following the regular building code amendment (69.8 per cent). Moreover, 51.7 per cent of the respondent believed that amending building code could make way for low-cost construction materials in New Zealand.

With a high aggregated mean value (M = 4.04) and standard deviation value (SD = 0.97), the study's findings also indicated that regular updates of building code would create the opportunity for the improvement of the quality of building materials. New Zealand performance-based building code is revised to ensure that the code is in conformity with best practice regarding the quality of construction materials (Bill et al., 2011). The high percentage of respondents that believed that the quality of construction work has increased may imply that the majority of building construction works in New Zealand comply with the building regulations with certified building materials. The report from Jenny (2019) supported the findings in this study regarding the availability of low-cost materials. However, the lack of market control could prevent the influx of low-cost construction materials (UNECE, 2015), coupled with the quality of material (APN, 2017a). The findings from the Friedman statistical test ($p = 0.001 < 0.05$) indicates that the null hypothesis should be retained. The summary of these findings from Friedman statistical tests analysis is shown in Tables 6.15 to 6.17.

Table 6.15: Friedman mean rank.

	Mean rank
Make way for a low-cost material	1.91

Improved material quality	2.42
Good work quality	1.67

Table 6.16: Friedman's test statistics[a]

N	116
Chi-Square	45.326
df	2
Asymptotic significance	0.001

Table 6.17: Descriptive statistics

Item	N	Mean	Standard deviation	Minimum	Maximum
Make way for low-cost material	116	4.02	0.791	1	5
Improved material quality	116	4.41	1.064	1	5
Good work quality	116	3.70	1.049	1	5

6.4.5. Organisational factors relating to building code amendment

Findings from the questionnaire show the percentage of respondent's opinions on organisational factors relating to building code amendment. About 70 per cent of the respondents strongly agreed that updating building code helps to reduce corruption tendencies. Although, the findings from this study vary from the results obtained by (Khan et al., 2010; Moullier & Krimgold, 2015; Sedlenieks, 2004) regarding corrupt practices in building regulatory system. Following building code amendments, 65.5 per cent of the respondents believed that international collaboration increased. The findings from the study aligned with the conclusion drawn by (IRC, 2010b) regarding improved international collaboration in Canada. The high response maybe as a result of technical complexity surrendering the practice of performance-based building code globally (Deroukakis, 2000; IRC, 2010b; Mumford, 2010).

Performance-based building code also makes it easier for the international market to share ideas and new technology (Khan et al., 2010). However, only 38.8 per cent holds the view that changes made to the building code reduced bureaucracy in the design approval process. The low percentage of respondents that agreed on reduced bureaucracy suggests that more improvement is needed. Also, most building code users and property owners are satisfied with the bureaucratic process around the implementation of the building regulation requirements in New Zealand (Gabrielle, 2018; Listokin & Hattis, 2005; Whanganui Chronicle, 2017). Additionally, 54.3 per cent believed that building code amendment creates the pathway to have planned resource availability.

The above findings on organisational factors relating to building code amendment ($M = 3.86$, $SD = 1.00$) imply that the New Zealand building code amendment has positive impacts on the organisational system. Friedman's test of the above findings ($p = 0.491 < 0.05$) shows that the null hypothesis should be rejected. Figure 6.7 and Tables 6.18 to 6.21 depicts the summary of these findings from Friedman statistical test.

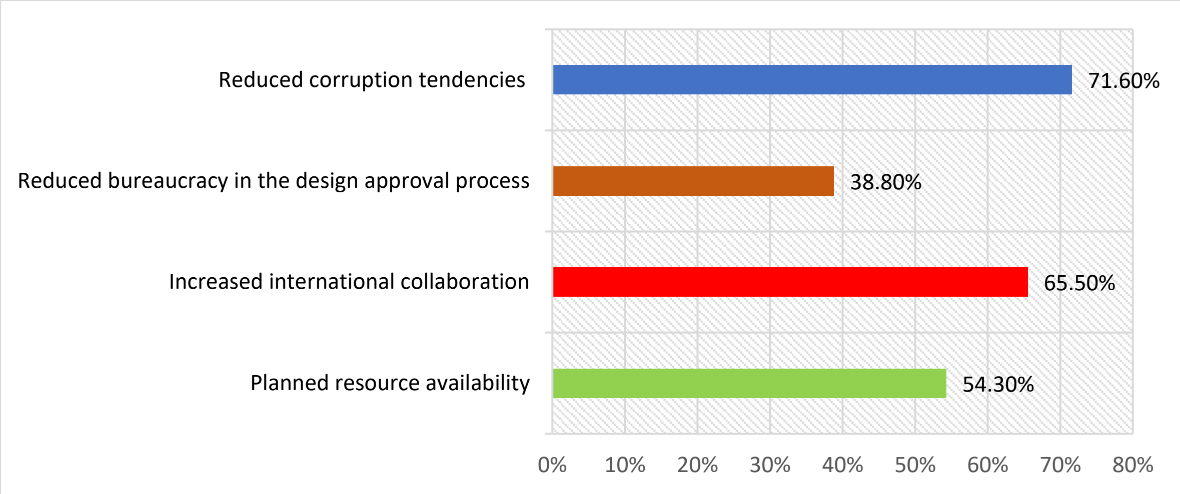


Figure 6.7: Organisational factors relating to building code amendment.

Table 6.18: Friedman mean rank.

	Mean rank
Planned resource availability	2.40
Increased international collaboration	2.31
Reduced bureaucracy in the design approval process	2.01
Reduced corruption tendencies	3.28

Table 6.19: Friedman's test statistics[a].

N	116
Chi-Square	84.114
df	3
Asymptotic significance	0.001

Table 6.20: Descriptive statistics.

Item	N	Mean	Standard deviation	Minimum	Maximum
Planned resource availability	116	3.78	0.988	1	5
Increased international collaboration	116	3.78	0.912	1	5
Reduced bureaucracy in the design approval process	116	3.38	1.116	1	5
Reduced corruption tendencies	116	4.49	0.974	1	5

6.4.6. Impacts of building code amendment on compliance and enforcement

To further understand the benefits of building code amendment, the participants were asked to rate the advantages of building code amendment regarding compliance and enforcement. A total of 71.6 per cent of the respondents strongly agreed that compliance with health and safety improved as a result of building code amendment. Also, 69.0 per cent of the respondents believed to a large extent that amending building code improves compliance with the use of the building code. Furthermore, 69.0 per cent of the respondents strongly agreed that regular building code updates increase the level of enforcement. While 65.5 per cent strongly believed that the enforcement process is strictly applied and the implementation process (56.0 per cent) improved following code amendment. The above findings suggest that a clear process of implementing building code increases compliance level and strengthens the enforcement process.

The high aggregated mean value (M = 4.29) and the standard deviation (SD = 1.02) may suggest that building code users understand the significances of complying with the building code regulations. The findings support the aim of building code amendment in New Zealand (MBIE, 2019h) and also aligns with the findings from (Ahmed et al., 2018; Hudson, Sutrisna, & Chawynski, 2020; Kenji, 2008) regarding compliance and enforcement. Although, there are raised concerns that building code amendment causes complexity in implementing the requirements as stipulated in the building code (Heijden et al., 2007; Spence, 2004). The analysis from the Friedman regarding the impact of building code amendment on compliance and enforcement ($p = 0.001 < 0.05$) shows that the null hypothesis should be retained. Figure 6.8 and Tables 6.21 to 6.23 shows a summary of the results.

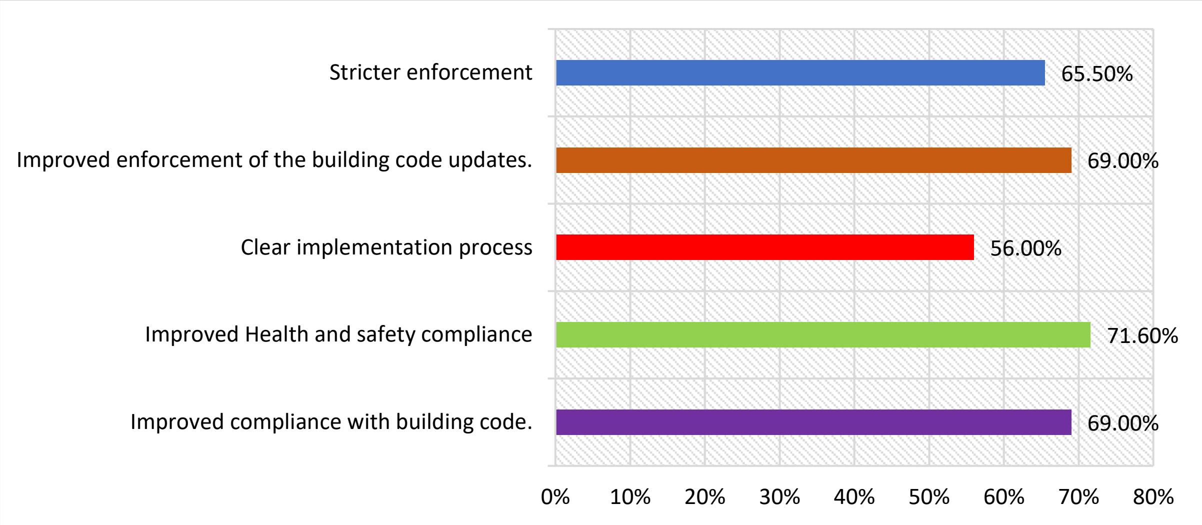


Figure 6.8: Impacts of building code amendment on compliance and enforcement.

Table 6.21: Friedman mean rank.

	Mean rank
Improved compliance with building code.	3.19
Improved Health and safety compliance	3.30
Clear implementation process	2.15
Improved enforcement of the building code updates.	3.26
Stricter enforcement	3.11

Table 6.22: Friedman's test statistics[a]

N	116
Chi-Square	68.152
df	4
Asymptotic significance	0.001

Table 6.23: Descriptive statistics.

Item	N	Mean	Standard deviation	Minimum	Maximum
Improved compliance with building code.	116	4.38	1.077	1	5
Improved Health and safety compliance	116	4.49	0.946	1	5
Clear implementation process	116	3.81	0.950	1	5
Improved enforcement of the building code updates.	116	4.45	1.007	1	5
Stricter enforcement	116	4.34	1.111	1	5

6.4.7. Efficacy of building code amendment relating to innovation and technology

While responding on the efficacy of building code amendments relating to innovation and technology, 77.6 per cent of respondents strongly agreed that changes to the building code create flexibility in the design and construction process. Also, 65.5 per cent, to a large extent, agreed that innovation in design and construction and construction methods (62.1 per cent) improved following the code amendment. However, 31.0 per cent of the respondents agreed that updating building code reduced the cost of design, construction, and installation, while 36.2 per cent believed that it promotes the use of local technology. The low percentage of the participants that believed that building code amendment promotes local technology and reduced cost of design, construction and installation may imply that the New Zealand building code needs to incorporated local technology while pursuing cost-benefit analysis before amending building code.

Regular building code updates increases design and construction flexibility (MBIE, 2014b) and enables innovative technology (Nikki, 2014) in the construction industry. Moreover, amending performance-based building code supports innovation and flexibility (Bill et al., 2011). Nevertheless, Khan et al. (2010) believed that it increases the cost of construction and design.

The high aggregated mean value and standard deviation (M = 3.9, SD. = 1.04) indicates that the New Zealand building code amendment promotes innovation, technology and flexibility. The outcome from the Friedman test ($p = 0.001 < 0.05$) shows that the null hypothesis should be retained. The summary of the findings is shown in Figure 6.9 and Tables 6.24 to 6.26.

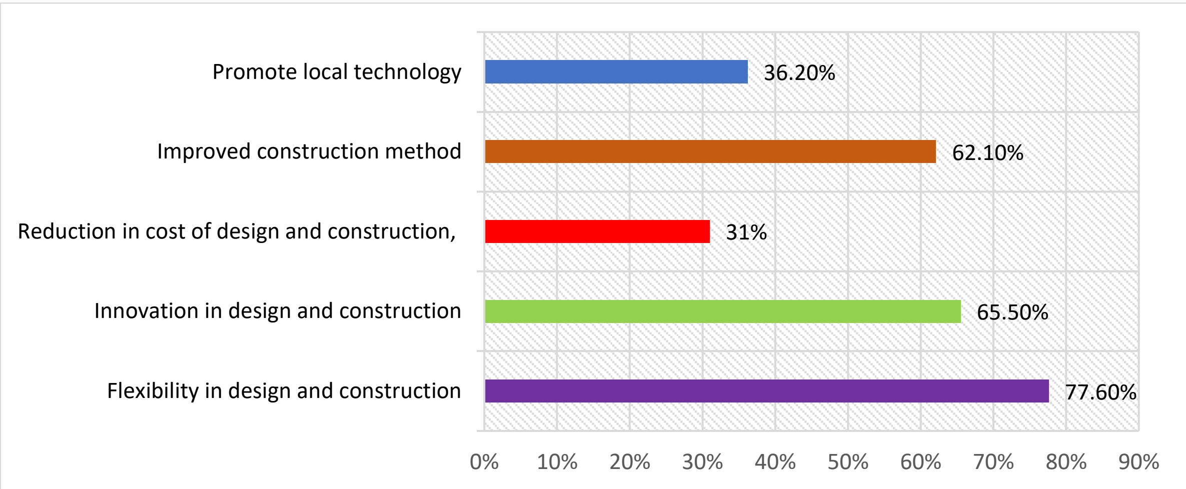


Figure 6.9: Efficacy of building code amendment relating to innovation and technology.

Table 6.24: Friedman mean rank.

	Mean rank
Flexibility in design and construction	4.00
Innovation in design and construction	3.66
Reduction in cost of design and construction	2.23
Improved construction method	3.66

Promote local technology	2.45

Table 6.25: Friedman's test statistics[a].

N	116
Chi-Square	144.346
df	4
Asymptotic significance	0.001

Table 6.26: Descriptive statistics.

Item	N	Mean	Standard deviation	Minimum	Maximum
Flexibility in design and construction	116	4.61	0.852	1	5
Innovation in design and construction	116	4.39	1.028	1	5
Reduction in cost of design and construction	116	3.31	1.247	1	5
Improved construction method	116	3.78	0.958	1	5
Promote local technology	116	3.43	1.136	1	5

6.5. Conclusion

New Zealand is located in an active seismic environment, which has prompted frequent building code amendments to reduce the impact of earthquake hazards. This study investigated the benefits of amending building code regularly in New Zealand. The benefits of building code amendment investigated were related to resilience, training, technical improvement, quality of construction materials, organisational factors, compliance and enforcement, and other factors relating to innovation and technology. The findings from this study indicated that regular amendments to the New Zealand building code have yielded significant results with emphasis on improved resilience, increased compliance level, improved flexibility in design and construction, improved the quality of construction materials, increased professional training and reduced corruption tendencies. Furthermore, this study serves as a useful guide to policy regulators and researchers who are exploring other aspects of regular building code amendments in New Zealand. The findings also promoted the effort of the code regulators in ensuring that the impact of natural hazards in the New Zealand built environment is reduced, and the country remained on the top as a core member in promoting the development of performance-based building code in the globe. Despite presenting many benefits of building code amendment, updating the code comes with some challenges that can be handled.

However, providing free to low-cost technical assistance to the building code users and raising awareness on the significance of building code amendment would go a long way in improving the benefits of building code amendment. Furthermore, the outcome from the study revealed that building code amendment in New Zealand has not adequately promoted the use of local technology in both design and construction. The local technology could be promoted by improving the existing technical process without altering the local creativity of the technology. Moreover, the survey respondents indicated the need to reduce the bureaucratic process associated with design approval, construction, site inspection and cost reduction. The study, therefore, recommends that hiring and training more technical skill professionals and reducing the unnecessary routine process would be significantly helpful in achieving the objectives of building code amendment in New Zealand.

In order to increase the benefits of building code amendments, there is a need to develop a capacity-building framework that could bridge the gap between the building code regulators and regulated. The study also discovered that there are some resentments that the negative impacts of frequent code amendments may outweigh the benefits of building code amendment. Concerns were also raised about the extent to which the building code regulators could offer free to low-cost technical assistance to the code users. These concerns raised would be addressed in future studies. Furthermore, the study recommends a follow-up study to understand the improvement following building code amendments, how the improvements are achieved, and the resource involved in the amendment process. Hence, building code amendment should be seen as a measure to reduce the impact of natural hazards and increase the sustainability of the resilient built environment. Improving on the identified factors would increase the rate of compliance with the building code and contribute intensively to disaster risk reduction in the built environment.

7. Unintended consequences of performance-based building code amendment in New Zealand.

This chapter was developed from Publication № 6, which has been submitted to *Journal of Performance of Constructed Facilities [under review].* This chapter aims to answer the research question RQ3 and research objective RO6.

Abstract

New Zealand building codes are often amended to ensure a resilient built environment. The changes in the building code have unintentionally affected the application and use of the amendments in the building code. The purpose of this study is to investigate the unintentional consequences of building code amendments in New Zealand and make adequate recommendations for improvement. The view of relevant building code users in the building code regulatory system on the negative consequences of building code amendments was analyzed in this study. In total, the study examined 116 survey questionnaires to explore the understanding of building code users on the unintended impacts of building code amendments. Findings from the study show that a high proportion of respondents strongly believed in the need to improve the unintended side effect of building code amendment with an emphasis on proactive training, bureaucracy in the design approval process, shortage of technical staff and increased code technical complexity. Hence, justifying the usefulness of the research. Based on

the findings from this study, it is evident that providing satisfactory technical guidelines and reducing regulatory deficiency within the building code authorities will help to reduce the negative impacts of building code amendments in New Zealand. The study concludes by stressing the significant impacts of unintended consequences of amending building code and emphasized informing the policy regulators on the need to improve the identified consequences of building code amendment.

7.1. Introduction

The performance-based building code has contributed significantly to the improvement of designs and construction by allowing an innovative and flexible approach in the application of building code requirements (Nwadike & Wilkinson, 2020d). The building code sets the minimum standards for all construction works and other related services (MBIE, 2014b).

Many countries have shifted to performance-based building code with the intent to reduce all regulatory bureaucracy (Gross, 1979; B. J. Meacham, 2010a), reduced cost (Jishnu Kumar Subedi, 2008; Nwadike et al., 2019a), promote innovation (Armstrong et al., 2017; Duncan John, 2000; B. J. Meacham, 2010a), an open international collaboration (Khan Raza Ali et al., 2010), meet societal expectations (Brian Meacham, Robert Bowen, Jon Traw, & Amanda Moore, 2005) and improve building performance (Meacham, 1998; B. J. Meacham, 2010a). With time, building code amendment becomes imperative as code changes help to provide efficient regulations in design, construction and other associated services within the building regulatory system. Building code amendments are necessary to improve the quality of buildings (Lee Neil, Bennett J.M., Jones M.S., Marston N.J., & Kear G., 2008; B. J. Meacham, 2010a; Mills, 2010), that would withstand any extreme environmental conditions, including earthquakes. MBIE (2019e) noted that amendments to the building code improves safety and provides safer solutions to have a resilient built environment. Amendments to building code have opened doors to the clarity of code requirements, flexibility, innovation, introduction to new products and improved regulatory process (Duncan, 2005; Brian Meacham et al., 2005; Sexton & Barrett, 2005). Similarly, the leaky building crisis in New Zealand showcased some degree of deficiencies in the building code and was adequately followed up with amendments in the building code and the associated compliance documents (Don Hunn, Ian Bond, & David Kernohan, 2002). The leaky building crisis is centred on weather-tightness deficiency issues where the moisture gets in between the outside walls, known as cladding, and the inside walls (Don Hunn et al., 2002; Real Estate Authority, 2020). The cost of repairing the leaky building crisis is estimated at forty-seven billion New Zealand Dollars ($47 billion), while about eighty-nine thousand buildings are estimated to have been affected (Cooper, 2009; Dyer, 2019).

However, building code amendments, to some extent, have triggered some unintended consequences that may have the tendency to limit the purpose of building code regulations, despite its numerous advantages. Within the context of this study, the unintended consequences of amending the building code are referred to as the unforeseen side effects as a result of building code amendment, especially in the practical application of the code requirements. These unintended consequences in building code amendment need to be addressed to reduce its severity on the building regulating authorities, code users and the entire built environment. The inadvertent impacts could be attributed to the performance-based building code as it is a well-known fact that this type of building code is still undergoing developmental process (Lawrance et al., 2014).

Reviewing building code requires further understanding of the changes (Lawrance et al., 2014), its application and various ways of complying with the new requirements. Lack of understanding of the new amendments may lead to the wrong interpretation, application and implementation of the new requirements in design and construction and resulting in non-compliance (Duncan, 2005). Also, poor understanding of the building code changes unintentionally creates room for poor interpretation of building code requirements (Mills, 2010). In some cases, the code users and the building officials are not adequately trained in line with the new modifications to the building code, leading the code officials to have limited knowledge in the new direction (Duncan, 2005; Michael Mills, 2010a). Williams (2016) argued that while the building regulations are tending toward stricter measures, efforts to train the code users are on the decline. The insufficient training of the technical, regulatory team as a result of building code amendment could have unknowingly caused negligence in providing satisfactory technical guidelines (Duncan, 2005) and assistance that will enhance the knowledge of the code users and encourage the reduction of the unintended consequences of building code amendment. Accordingly, an increase in the cost of design, construction and approval process relating to building code amendments could lead to an unintended cutting of corners by building code users in other to outsmart the system (Carla Williams, 2016; McLean, 2017). This practice is evident in situations where the cost of complying with the amending building code requirements outweighs the cost of non-compliance (APN, 2017a; Nwadike & Wilkinson, 2020b). Building code amendments towards allowing more application of innovative practice in design and construction, in some cases, have shown situations where the innovative practice unintentional outpacing the readiness of both the construction industry and the building code regulatory bodies (Duncan, 2005; Nwadike & Wilkinson, 2020d). For example, the leaky building crisis in New Zealand was primarily caused by changes made to the timber treatment for wall framing in building construction (Consumer Build, 2004; Don Hunn et al., 2002). The leaky home crisis was further exacerbated as the *Pinus Radiata* timber, when wet, has low resistance to rot, and due to lack of technical experience, the claddings were not installed correctly according to specifications (Molloy, 2014).

Alter (2018) opined that changes made to the American building code unintentionally increased cost, causing some builders to reduce and manipulate the square footage of homes. In Turkey, Smith (1999) believes that the amendments to the building code caused widespread destruction in the 1999 Kocaeli Turkey earthquake. However, Ilki and Celep (2012) were of the opinion that the poor performance of buildings in Kocaeli, Turkey, is not directly associated with deficiencies in the building code requirements but compliance. Pearson and Delatte (2005) pointed out that lack of robust provisions for structural integrity in the changes made to the building code unintentionally resulted to the collapse of Ronan Point Apartment in London. Accordingly, the unintended consequences of earthquake-prone building legislation lead to the demolition of some heritage buildings in Invercargill, New Zealand, because of the cost of maintenance and putting the building up to the standard required by the legislation (Aigwi, Filippova, Ingham, & Phipps, 2020).

The New Zealand building codes have been subjected to changes by either adding new requirements or improving the existing technical requirements. These changes are aimed at improving, streamlining and deregulating the quality control systems for better services. Despite the good intentions of amending the building code, there exist some unintended consequences of these changes in the use and application of the building code requirements that have presented a challenging situation that needs attention.

The efficacy of building code amendment may depend on how these unintended consequences are investigated, identified, and provided with adequate solutions that will reduce the effects, if possible, eliminate the negative impacts. Some of these unintended impacts could be unique to the New Zealand building code as a result of the biannual amendment process. From the above context, this study focal point is underpinned by investigating the unintended consequences of building code amendment, the causes, and provide suitable recommendations. The study used a questionnaire to assess the views of the relevant stakeholders involved in building code. The findings from this study offer insight into how the unintended consequences can be handled.

This study contains an abstract that provides a summary of the research. The introduction section gives comprehensive background information on the relevances of studying the unintended consequence of building code amendments, and the research objectives describe what the study expects to achieve. The literature review helps to identify, evaluate and synthesize existing literature within the building code regulatory system. The strategies and process used in data collection to achieve the research objectives of this study were clearly stated in the research method section. The findings and discussion section presents the results outcomes with adequate in-depth discussions of the research findings. The main points of the research findings and their practical implications, study limitations, and future studies were provided in the conclusion section.

7.1.1. Research objectives

i) To explore the unintended consequences of building amendments.

ii) To make adequate recommendations on how to minimise the impact of the unintended consequences of building code amendments, compliance documents and standards.

7.2. Literature review

This section gives insight into the existing conceptual background relating to building code amendments and the associated complexities.

7.2.1. Building regulatory framework in New Zealand

Building regulatory system in New Zealand aims to achieve safer, healthier and affordable buildings (MBIE, 2016d). The building regulatory framework demonstrates how all building designs, constructions and other related works can comply with the building codes, standards and compliance documents. The New Zealand building regulatory framework comprises the Building Act, the Building regulation and the building code while providing the responsibilities of all the parties involved in regulating the building code (MBIE, 2014b). The building Act sits at the top in the New Zealand building regulatory framework, followed by building regulations and the building code. The Building Act offers all the necessary provisions, including legislations needed in regulating all building works within the building and construction industry and the building regulations contains details for building controls while the building code sets the minimum performance criteria all building works must satisfy (MBIE, 2014b, 2016d).

The building code contains 37 technical clauses and two preliminary clauses with each of the technical clauses has three different levels of requirements that must be satisfied (i) the objectives criteria each building must achieve; (ii) the functional requirements each building must perform to meet the objective criteria, and (iii) the performance criteria each building must meet by achieving the objectives and the functional requirements (MBIE, 2014b). The Ministry of Business, Innovation and Employment (MBIE) is empowered by the law to oversee, regulate and maintain the activities of the building control system, with other agencies having a quasi-regulatory role under the supervision of the MBIE (MBIE, 2016d). The other agencies include district and city councils, government agencies, building practitioners and the construction industry (MBIE, 2016d).

7.2.2. Building code complexity and its implications

Complexity in understanding the technical requirements of building code and its application is a global issue that needs to be addressed. The nature of building code is complex, especially as it tries to cover broader areas within and beyond the construction industry (McLean, 2017). Other factors also constitute complexity in the building code regulation. McLean (2017) believed that the developmental and enforcement process of building code adds complexity to the building code. Achieving the primary purpose of building code and aligning the code with the pace of technological advancement and innovation, the building code has been consistently subjected to amendments. However, many opined that regular building code amendment had caused complexity in the code requirements (Craig DeFriez, 2014; Heijden et al., 2007; Pence, 2006), even though improvement to the code requirements enhances a safer built environment (Spence, 2004).

Also, Pence (2006) believed that five years amendment interval would reduce code complexities as it will offer more time to the code users to have a full understanding of the code requirements before the next amendment. Building code complexities may also be a result of stipulating unrealistic measures as code requirement or introducing a new concept that is not practically applicable (Lawrance et al., 2014) without an adequate training programme for the code users and the building officials. Building code complexities could be a result of a paradigm shift from prescriptive-based code to performance-based code. The prescriptive-based code outlines the systematic procedures of achieving code requirements. In contrast, performance-based code only states how a structure should behave without outlining the step by step process of achieving the purpose. With the recent wave of technological innovation in the building industry, the building code requirements are becoming complex, such that many building code users have been forced to use computer software without adequate fundamental knowledge of the code requirements (Pence, 2006).

Furthermore, adopting building code of other countries or localities without adequate technical capacities and adjustments of the adopted code to fit into the adopting country context could lead to code complication and difficulty in implementation (Moullier & Krimgold, 2015; Spence, 2004). Also, unclear statements and confusing terminologies in building code, standards, and compliance documents that are not well understood by the code users may present such code as non-user-friendly. Searer (2006) considered some of the building code provisions as poorly worded, ambiguous and pointlessly complex. The quest to achieve full accuracy in design analysis and maximum safety have paved the pathway that allowed the academia and regulatory agencies to amend the code in such a manner that seems practically challenging to the industry with several volumes of provisions (Craig DeFriez, 2014).

7.2.3. Implications of code complexity

Technical complexity in building code requirements has increased over time as technological advancement becomes inevitable in the building regulatory system. The technological advancement in the building code has optimized the design, implementation and construction process efficiently while unavoidably driving the building code towards more technical complexities (Rahman, 2010). The complexities could be a result of advancements in building components, innovative systems, multi-disciplinary integration and the desire for novelty designs and construction for the built environment (MBIE, 2013; McLean, 2017; Rahman, 2010). Complexities in the building code have caused misinterpretations of code provisions from all parties involved in the use of building code (Craig DeFriez, 2014; Listokin & Hattis, 2005), which have led to confusion and error in the application (McLean, 2017). These complexities can diminish the rate of accuracy in design analysis and safety measures which are the primary aims of improving the building code requirements (Craig DeFriez, 2014), and increase the unintended consequences of building code amendments. In many situations, there are reports of cost increment because of stringent and complex building code requirements (Arlani & Rakhra, 1988; Khan et al., 2010; Listokin & Hattis, 2005; McLean, 2017). The cost increase affects all the relevant stakeholders such as the building officials, code users and the building owners. Hence, there is a need to review and remove any noticeable complexity in the building code requirements.

7.2.4. The solution to building code complexities

Following the unintended impacts of code complexities to the code users, building officials and the built environment, it becomes imperative to find various ways of ameliorating the complexities in the requirements of building code and its application. Craig DeFriez (2014) believed that a reasonable balance between theoretical knowledge and practical applicability of building code requirements would help to reduce complexity in building code requirements. An effective balancing method to reduce building code complexity will include the interaction between planning, operation, design, and construction. This method will help the policy regulators to be mindful of how the amended requirements can be easily applied practically. However, there are other practical measures to reduce building code complexity, such as; (1) involving and carrying all the relevant stakeholders along during and after the amendment process and allowing their contributions and opinions to count. (2) empowering the code users and building technical staff through proactive training programmes, incentives such as reduction of compliance fees for voluntary compliance, free or low-cost technical support. (3) collaborating with both local and international players in the building code field while fostering a learning environment. (4) ensure that the building code is effectively enforced, implemented, simplified and amended accordingly to keep the code updated with the speed of technological innovation. (5) consult with all relevant stakeholders on the best practice to enhance compliance. (6) Inform the building owners of their rights and how to ensure that compliance with the building code provisions is strictly followed.

Furthermore, Searer (2006) suggested removing poorly worded and unnecessary building code provisions while aiming at improving clarity and simplifying the code requirements. Therefore, it is necessary that the policy regulators and other associated entities will use the opportunities of building code amendment to reduce the risks related to the unintended consequences by simplifying the noticeable complexities in the building code requirement to enhance the benefits of building code amendments.

7.3. Research method

This study is ontologically underpinned by the philosophical nature of reality surrounding the performance-based building code by considering different individual perspectives and the social construct on the research objectives (Berry & Kincheloe, 2004a; Creswell & Poth, 2016; Jackson, 2013). Accordingly, the study considered the diversity of individual perception of the research topic under consideration (Jackson, 2013). The study carefully considered the epistemological stance of the research by seeking for new and existing valid knowledge of the research topic (Oliver, 2010). The epistemology study was carried out by examining the relationship between the research topic and how to achieve the research objectives (Bryman, 2008; Ormston et al., 2014). Within the New Zealand building code context, both the ontology and epistemology stance seeks to demonstrate that there are unintended consequences whenever the building code is amended. This study examined if this reality can be seen, acknowledged and understood based on the perspectives of building code in New Zealand.

In consideration of the research objectives of this study, the aim of the research topic is underpinned by investigating the unintended consequences of building code amendment in New Zealand. In achieving this purpose, an interpretative research approach was adopted using a closed-ended questionnaire to gather meaningful information's necessary for this study. The participants of the questionnaire survey must be individuals that either use or regulates the building code and must have practised with the New Zealand building code in New Zealand. These selection criteria were set to ensure that only individuals with adequate knowledge of the New Zealand building code will participate in the questionnaire survey. The selection criteria were ensured by stating it on the participant's information sheet, consent form and in the questionnaire survey distributed to the participants.

7.3.1. Data collection

The closed-ended questionnaire was distributed to the building code users that regulate or use the building code in practice to investigate their opinions regarding the unintended consequences of building code amendment, the associated compliance documents and standards. A closed-ended questionnaire was used because it is a cost-effective method that offers the opportunity to gather a large quantity of data within a short period (Saul McLeod, 2018; Susan Farrel, 2016).

The questionnaire method allows the respondents to answer the questions at their convenient time without interrupting their activities. The questionnaire survey was selected as a method of data collection for this study, based on: (i) the targeted respondent's are the building code users who have reasonable experience and knowledge of New Zealand building code and are competent to provide relevant information based on the selection criteria (Preston, 2009), (ii) the nature of the research where many building code users could be reluctant to discuss the research topic and would prefer to be anonymous, (iii) a way of gathering large information as much as possible, (iv) the availability of the intended participants, as it was be preferred to be completed at the respondent's convenient time, and (v) considering the way the questions in the questionnaire was constructed to achieve the research objectives.

The questionnaire survey was divided into seven categories to capture all the essential pieces of information such as the participant's profiles, technical guidelines and assistance, education and incompetence, cost increase, weak enforcement and compliance, poor planning, and regulatory deficiency within the authorities. The questionnaires were distributed face to face and online. The online distribution was necessary as it provides an opportunity to a broader community of relevant stakeholders. It is estimated that it will take approximately 45 minutes to complete each questionnaire. In choosing the participants for this study, a purposeful sampling technique was adopted as it allows respondents to be selected based on their knowledge, experience and are willing to give insightful details within the research topic (Babbie, 2013; Lawrence Neuman, 2014; J. Maxwell, 2013).

A total of 250 closed-ended questionnaires were distributed to the building code users, and 121 questionnaires were returned, out of which 116 questionnaires were completed and used in the study analysis. Five returned questionnaire were not used in the analysis because the questions in the questionnaire were not completely answered. The questionnaire returned a response rate of 48.4 per cent above the average questionnaire response rate of 33 per cent (Nigel, 2019). For this study, a questionnaire survey provided the primary source of data. At the same time, the literature review was used to retrieve existing literature relating to the research topic as secondary data.

7.3.2. Data analysis

The IBM Statistical Package for Social Sciences (SPSS) was used to analyse the response from the collected questionnaire survey. The questionnaire responses were gathered and arranged in a number coded format before entering it into the SPSS spreadsheet manually, where each respondent's answers were presented in a column against each question in row format. Also, the spreadsheet was doubled checked to maintain a high level of accuracy. Moreover, a statistical tool called the Friedman test was used to assess the significant difference of each questionnaire item (Friedman, 1937) would have on the unintended consequences of building code amendment in New Zealand. This study set a null hypothesis that there will be no significant difference in each of the measured questionnaire items will have on the unintended consequences of building code amendment. As a decision rule, the null hypothesis should be rejected if the probability value (*p*) is less than 0.05.

7.3.3. Cronbach alpha reliability check

For this study, the Cronbach alpha coefficient (α)technique was adopted to measure the level of internal consistency reliability of each item in the questionnaire (Gliem & Gliem, 2003; Tavakol & Dennick, 2011), and the reliability check was carried out in SPSS. The Cronbach alpha coefficient for reliability check can be expressed as:

$$\alpha = \frac{K.\overline{C}}{\overline{V} + (K-1).\overline{C}} \geq 0.7 < 0.8 \tag{1}$$

Where K is the number of questions, $\overline{C}$ is the average covariance among the items, $\overline{V}$ is the average variance of the items.

The study shows a Cronbach's α coefficient of 0.852 > 0.7, which indicates a good level of internal consistency between all the questionnaire items measured (Gliem & Gliem, 2003), as shown in Table 7.1.

Table 7.1: Friedman test case processing summary for unintended consequences of building code amendment.

		Case processing summary	
		No. of participants	%
Case	Valid	116	100.0
	Excluded	0	0.0
	Total	116	100.0

		Reliability statistics	
	Cronbach's Alpha	Cronbach's Alpha Based on Standardized items	No. of questions
	0.852	0.853	25

7.3.4. Respondents profile

The questionnaire participants were mainly distributed across structural engineers (50%), geotechnical engineers (9.50%), architects (1.70%), building and consulting engineers (1.70%), licenced building officials (6%), project managers (12.90%), building contractors (3.40%), local authorities (7.8%) and academic/researchers (6.90%).

Regarding the participant's organisational position, 34.5% of the participants are staff, while 17.20% are in director and middle management positions, respectively. Also, 14.70% of the questionnaire respondents were in the supervisor, and 12.90% are in a senior management position. Similarly, the completed and returned questionnaire shows that 29.30% of the respondents have between 6 to 10 years of working experience, whereas 14.70% have between 16 to 20 years of working experience in their profession. Furthermore, 16.40% of the respondents have above

20 years of working experience. Also, 19.80% of the questionnaire respondents have a maximum of 5 years and between 11 to 15 years of working experience, respectively. The organisational position and years of working experience of the questionnaire respondents indicate that majority of the participants possess substantial knowledge of the New Zealand building code and the associated compliance documents.

7.4. Findings and discussions

This study used a Likert scale to weigh the response of the questionnaire respondents by setting the "strongly agree" as 5 and the "strongly disagree" as 1, respectively. The Likert scale allowed the questionnaire participants to freely expressed the extent of their opinions regarding each question in the survey (Likert Rensis, 1932). The SPSS analysis of the survey responses regarding the unintended consequences of building code amendments in New Zealand is presented below.

7.4.1. Insufficient education and incompetence's

The questionnaire participants were asked to evaluate the unintended consequences of building code amendment regarding insufficient education and incompetence of the building code users, 63.8 per cent of the respondents strongly believed that there is a lack of proactive training on building code updates, standards and the associated compliance documents. This practically implies that lack of proactive training leads to inadequate knowledge and understanding on how to implement new changes in the building code requirements. Similarly, 55.2

per cent, to an extent, agreed that poor awareness regarding building code amendments is a contributing factor to the unintended consequences of building code amendment. Also, 53.4 per cent of the survey respondents have the opinion that lack of competence as a result of inadequate training both on the code users and the building officials contributes to the unintended consequences of building code amendment in New Zealand. Equally, 53.4 per cent of the questionnaire respondents strongly agreed that the shortage of required professional skills and 42.2 per cent agreed that there is a shortage of non-professional skills as it contributes to the negative impacts of building code amendment in New Zealand.

The findings in this study regarding poor awareness following building code amendment are in line with previous studies by (Samasoni, 2017). In New Zealand, the Building Industry Authority recognised the importance of sufficient training to improve technical knowledge regarding building code amendments after the leaky building scenario (Consumer Build, 2004). Duncan (2005) acknowledged that building code users do not have full knowledge of the building code requirements. A better understanding of building code changes is essential (Heijden Van der & De Jong Jeroen, 2009; NCBCS, 2018b), especially as building code updates are used to facilitates innovative techniques that are widely accepted in design and construction (B. J. Meacham, 2010a). Furthermore, the competency of building code users is essentials as the code, standards and compliance documents undergo consistent amendments. Spinardi and Law (2019) stressed the need for improved competency in the building and construction industry, as (Duncan, 2005) believed that lack of competent workforce characterised the New Zealand building industry that resulted in leaking building situation. Due to the

New Zealand population, there is always an issue of shortage both in professional and non-professional skills. Kris Hudson and Jeffrey Sparshott (2015) acknowledged that the shortage of construction workers makes it tough to deliver projects within the stipulated timeframes. The increasing requirements and regular amendments within building code practice could have pushed the line for skill shortage (Carla Williams, 2016). Figure 7.1 shows the outcome of the survey on the unintended consequences of building code amendment on insufficient education and incompetence's.

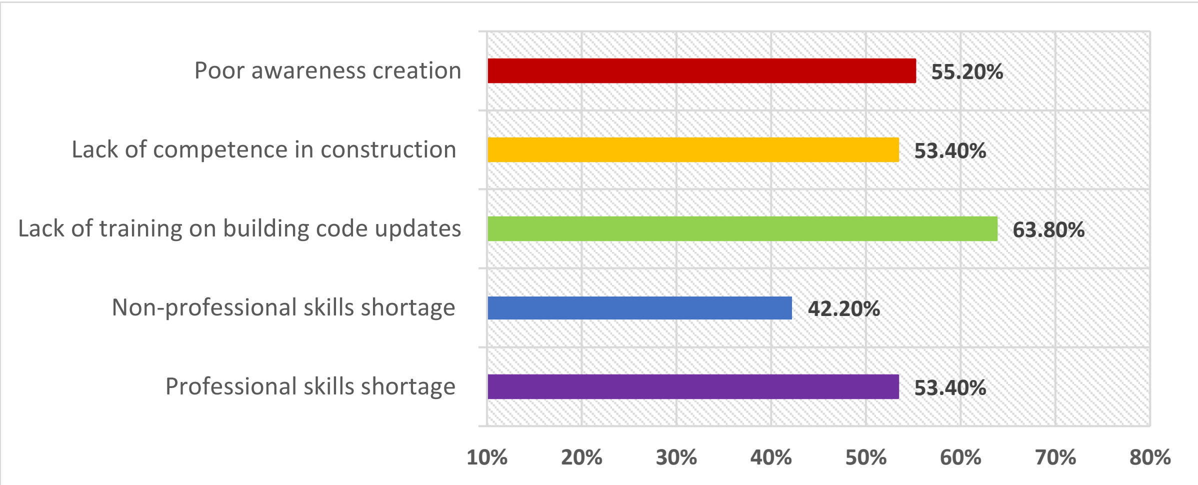


Figure 7.1: Responses on insufficient education and incompetences.

From the above findings on the unintended consequences of building code amendment following insufficient education and incompetence, the aggregated mean value of 3.91 and standard deviation value of 1.01 indicates the need to improve on the quality and method of education following building code amendment. Improved quality of education will help to enhance the competency of the code users and maximise the benefits of reviewing building code, compliance documents and standards. Based on the results from insufficient education and incompetence's, the Friedman test in this study (P = 0.001 < 0.05) indicates that the null hypothesis should be retained, as shown in Table 7.2.

Table 7.2: Friedman test results for insufficient education and incompetency.

Friedman test results	
	Mean rank
A1	2.64
A2	2.64
A3	3.70
A4	2.46
A5	3.56
	Test statistics
N	116
Chi-Square	83.095
df	4
Asymptotic significance	.001

N = Number of respondents, df = degree of freedom

7.4.2. Cost increment in the implementation of building code updates

Finding from the returned questionnaire reveals the percentage of the survey participant's opinion on the cost increment following the implantation of building code amendment in New Zealand. In total, 62.1 per cent of the survey respondents strongly agreed that building code amendment increases the cost of design, construction and other related services. Further, 52.6 per cent of the survey respondents are of the opinion that lack of incentives such as financial and technical assistance to subsidise the increase in cost following the building code amendment contributes to the unintended consequences surrounding building code amendments in New Zealand. Also, some of the respondents (45.7 per cent) believe that insufficient financial resource creates a set-back towards adopting, enforcing and implementing the new changes to the building code. The practical implication of this finding in this study is that at a point where the cost relatively high, it may have the tendency of discouraging the building code users from applying and implementing the new changes in the building code requirements. The high proportion of participant's that believed that building code amendment comes with cost increment suggests that cost is an issue the policy regulators should consider before, during and after updating building code, standards and compliance documents, as shown in Figure 7.2.

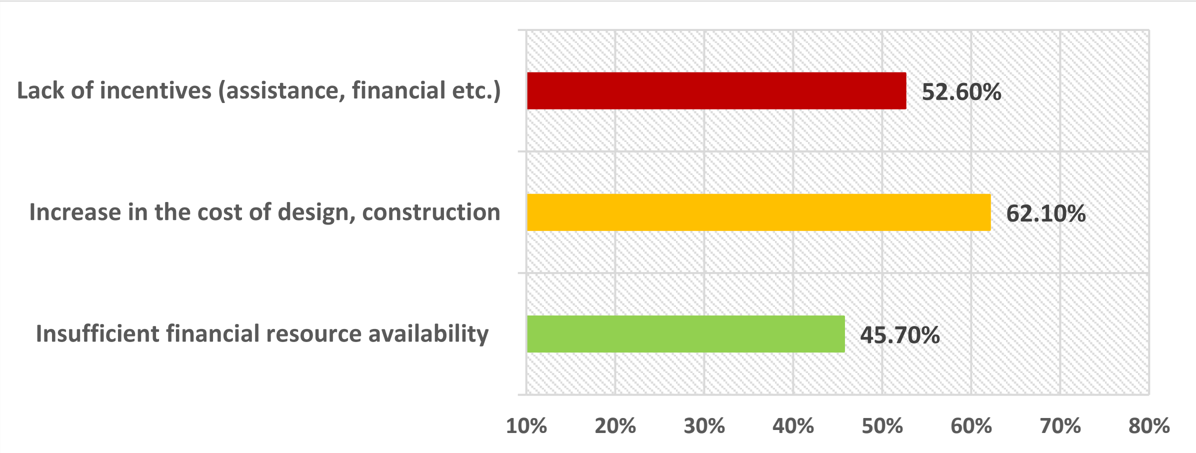


Figure 7.2: Cost increment in the implementation of building code updates.

The above findings aligned with the previous studies cost increment following building code amendments (Khan Raza Ali et al., 2010; Theckethil, 2006). Some of the cost resulting from building code changes are attributed to either proposing new innovative techniques to achieve compliance based on performance-based building code (Duncan, 2005), the cost in design and construction method due to increases requirements (Khan Raza Ali et al., 2010; Listokin & Hattis, 2005; Moullier & Krimgold, 2015; NCBCS, 2018b), cost of comprehensive information, clarity and guidance (Mills, 2010) or regulatory, administrative cost (Khan Raza Ali et al., 2010). Although, the Ministry of Business, Innovation and Employment (MBIE) has given some incentives in terms of making some of the building standards free to the users (MBIE, 2019f). However, the findings in this study suggest that more efforts are needed in making all the building standards and other related materials free of charge. The incentives could also be extended to providing financial resources in terms of reducing financial requirements to code users that fully comply with the new building code requirements and providing of more educative technical workshops that will offer more details to building code changes. Providing financial resources helps to adopt new building code requirements (Pam Williams, 2020). The practical consequences of these findings is that increasing cost as a result of amending the building code will discourage compliance with the building code requirements, especially where the cost of applying the new requirements outweighs the cost of non-compliance (Nwadike & Wilkinson, 2020b).

From the results analysed above, the relatively high aggregated mean value (M = 3.89) and standard deviation (SD = 1.04) indicated that there is always a cost increase associated with the implementation of new updates in the building code, standards and compliance documents. Furthermore, the findings in this study reveal that the cost of implementing new building code requirements contribute immensely to the unintended consequences of building code amendments in New Zealand. The Friedman test in this study ($P = 0.001 < 0.05$) suggests that the null hypothesis should be retained, as illustrated in Table 7.3.

Table 7.3: Friedman test results for cost increment in the implementation of building code.

Friedman test results	
	Mean rank
B1	1.78
B2	2.41
B3	1.78

	Test statistics
N	116
Chi-Square	40.592
df	2
Asymptotic significance	.001

N = Number of respondents, df = degree of freedom

7.4.3. The weak enforcement and compliance with building code amendment

The questionnaire respondents in this study expressed their personal views on the impact of unforeseen circumstances facing building code amendment on enforcement and compliance level following building code amendments in New Zealand. From Figure 7.3, the survey respondents (54.3 per cent) to some extent agreed that poor implementation of new changes to building code is a result of the weak enforcement system. According to 51.7 per cent of the respondents, weak compliance with the changes in building code regulations could have a negative impact on building code updates. Also, 45.7 per cent of the respondents believe that leniency in the enforcement of building amendments could be a contributing factor that encourages non-compliance with the building regulations. Similarly, some of the questionnaire respondents (45.7 per cent) are of the view that property owners show an unwillingness to comply whenever the building code and the associated compliance documents are amended. Furthermore, responses from the survey respondents show that only 36.2 per cent agreed that poor health and safety compliance constitutes an unintended consequence of amending building code. Figure 7.3 shows the Responses of the survey participants on Weak enforcement and compliance with building code amendment.

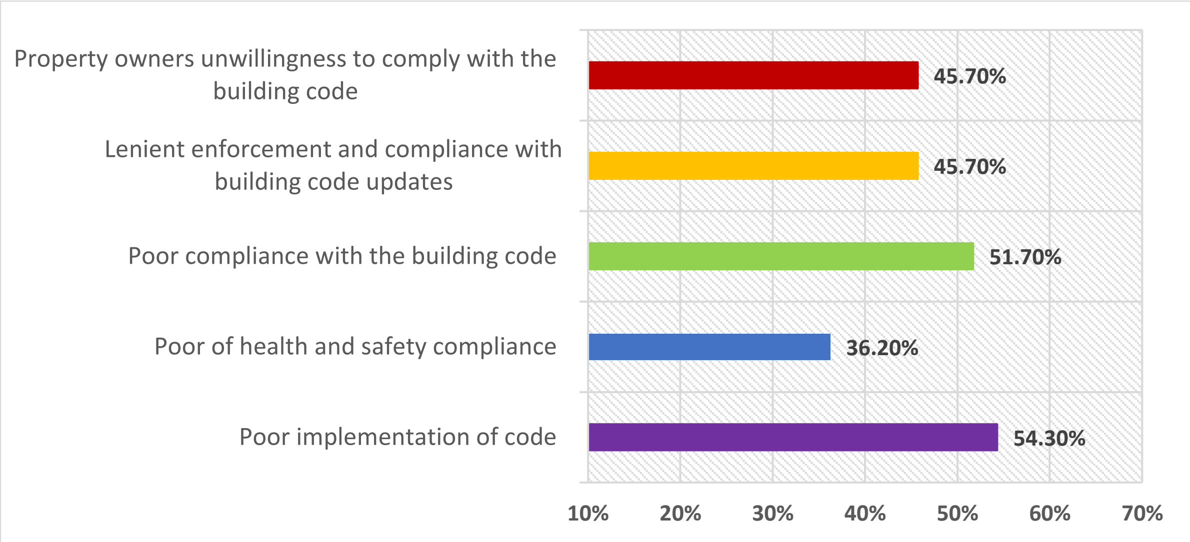


Figure 7.3: Responses on Weak enforcement and compliance with building code amendment.

The findings in this study suggest that poor implementation of building code provisions has exacerbated the unintended consequences of building code amendments, mainly when the users do not thoroughly understand the new requirements. However, many factors contribute to poor implementation of building code after amendments, such as lack of understanding (Chmutina & Bosher, 2015; Jones & Vasvani, 2017b), ignorance (Bilham, 2013), code complexity, corruption, societal development and enforcement (Jones & Vasvani, 2017b). Duncan (2005) believed that the effective implementation of new building requirements needs systematic training for all relevant stakeholders. Leniency in building code enforcement could lead to weak compliance, as (Carla Williams, 2016) noted that there is more attention to building code amendment compared with less concern on enforcement. Proactive enforcement with strategic measures help to avoid weak compliance and embed compliance consciousness in the building industry (Heijden Van der & De Jong Jeroen, 2009). Besides, the study outcome also suggests that weak enforcement and poor understanding of building regulation changes could inspire the building owners not to comply with the new provision. The policy regulators and the local authorities must ensure that buildings without compliance certificate cannot be sold or purchased to increase the willingness of building owners to comply with the new provisions of the building code (MBIE, 2016e). Hence, there is a need to advise the property owners toward the benefits of compliance. Arlani and Rakhra (1988) recognised that building code amendments have rational impacts on property owners, which can be positive in terms of reduced building cost, increased safety level, reduced cost of information, provision of clarity or negative impacts in terms of more innovative technical requirements that demand particular skill and economic consequences. The proportion of the respondents that thinks that there is poor health and safety compliance demonstrates that it is among the least issue that leads to weak enforcement and compliance in New Zealand. Although, the study recommends regular health and safety review to enhance building code practice.

The above findings reveal an aggregated mean value of 3.54 and a standard deviation value of 1.05, which implies that weak enforcement and compliance culture promotes unforeseen consequences of building code amendment in New Zealand. Findings from the Friedman test ($P = 0.004 < 0.05$) implies that the null hypothesis should be retained, as demonstrated in Table 7.4.

Table 7.4: Friedman test results for the weak enforcement and compliance with building code amendment.

Friedman test results	
	Mean rank
C1	3.05
C2	3.14
C3	3.20
C4	2.60
C5	3.01
	Test statistics
N	116
Chi-Square	15.393
df	4
Asymptotic significance	.004

N = Number of respondents, df = degree of freedom

7.4.4. Inadequate technical guidelines after building code amendment

Responses from the surveyed participants showed that the respondents considered the inadequate technical guidelines following building code amendment as a high contributing factor to the unintended consequences of building code amendment, as shown in Figure 7.4.

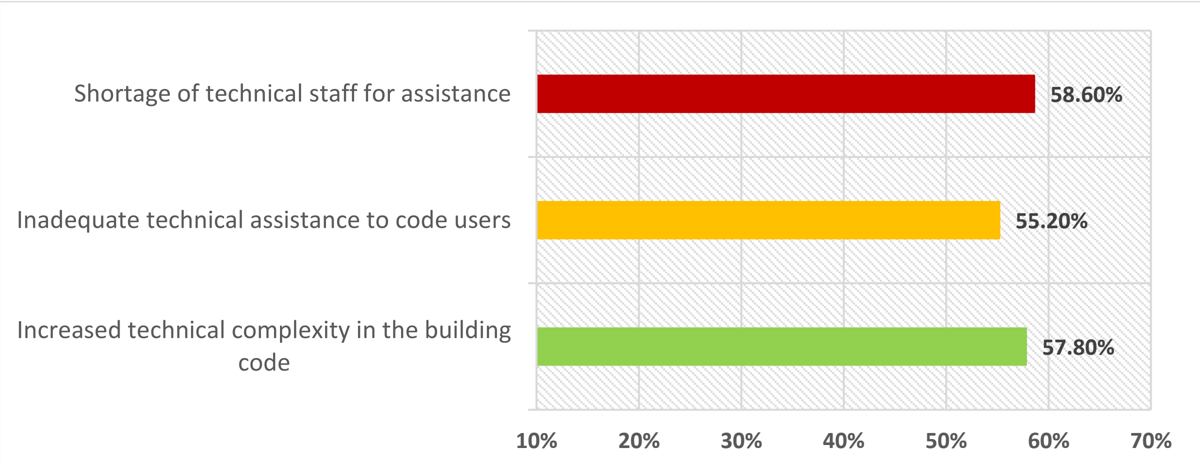


Figure 7.4: Inadequate technical guidelines after building code amendment.

A total of 58.6 per cent of the respondents identified that the shortage of technical building officials affected the kind of support the code users receives whenever there is any change to the building code. Following the new building regulations that require improvement on the building professionals administering building-related activities (Nick Smith, 2014), there have been reports on the shortage of technical building officials and the struggle of councils to meet their statutory timeframe for building activities (Georgina Campbell, 2019; Krimgold, 2011). The situation becomes difficult as the country is undergoing a period of construction boom (RNZ, 2018). The percentage of the respondent's that agreed that shortage of technical staff is a challenging issue implies that both the government and the regulating agencies need to step up with an efficient system of educating the building professionals about the new changes in the building code. The shortage of technical staff in the context of this study suggest that building code users are given limited assistance and guidelines on how to implement the new code requirements. The findings in this study also suggest that the shortage of technical staff could also be linked with their inability to apply the new building code provisions.

Other respondents (57.8 per cent) believed that the increase in technical complexity in the building code increases the level of non-compliance as a result of a poor understanding of building code requirements. Building code amendment either reduce or increase the technical complexity in building code requirements. With the increasing number of changes in the building code, technical code complexity may increase (Heidebrecht, 2003; Jones & Vasvani, 2017b), and lead to error in the application of the building code requirements (McLean, 2017). The developmental and amendment process of building code may exacerbate the code complexity (McLean, 2017). The complexity in the building code may result in illegal activities such as cutting corners, conflicts in the interpretation of new building code requirements, confusion on how to achieve the requirements, unnecessary delays in design and construction method approval, gives an opportunity for corruption in the building regulatory system (Samasoni, 2017), non-compliance and enforcement (Liu, Meyer, & Hogan, 2010).

In the context of findings in this research, the study suggests for a call to simplify the technical provisions of the code and a tool to measure the code complexity before the amendment process in other to reduce the negative impacts of regular changes in the building code. The code complexity measure will help to reveal areas that constitute difficulties in the application of building code provision following building code amendments.

Accordingly, 55.2 per cent agreed that the lack of adequate technical assistance to the building code users on the new code requirements following building code amendment poses a challenge in implementing the new updates. The result of this study aligned with the previous studies regarding the lack of technical assistance (Benge, 2001; Heidebrecht, 2003; Parajuli, Bothara, Dixit, Pradhan, & Sharpe, 2000). Although the MBIE and local councils provide some form of supports, the findings in this study call for improved technical assistance with new building code requirements to enhance implementation and compliance. The technical assistance may be in the form of interpretation of code requirements, continuous training, and consistent inspection (Olshansky, 1998).

From the above findings, the study shows a high aggregated mean value (M = 4.06) and standard deviation (SD = 1.07), which primarily demonstrates the importance of providing proactive technical guidelines to the building code users. Findings from this study will also inform the building code policy regulators on the necessity of making provision for an increased technical guideline for the code users before building code amendment, as it offers an opportunity to minimise the technical complexity in building code provisions. Based on the study findings, the Friedman test ($P = 0.001 < 0.05$) shows that the null hypothesis should be accepted, as shown in Table 7.5.

Table 7.5: Friedman test results for inadequate technical guidelines after building code amendment.

Friedman test results	
	Mean rank
D1	1.76
D2	2.11
D3	2.13
	Test statistics
N	116
Chi-Square	14.0
df	2
Asymptotic significance	.001

N = Number of respondents, df = degree of freedom

7.4.5. Poor planning, quality and changes in construction materials

Figure 7.5 shows the proportion of the respondent's opinion on how poor planning and quality and changes in construction materials contribute to the unintended consequences of building code amendment in New Zealand.

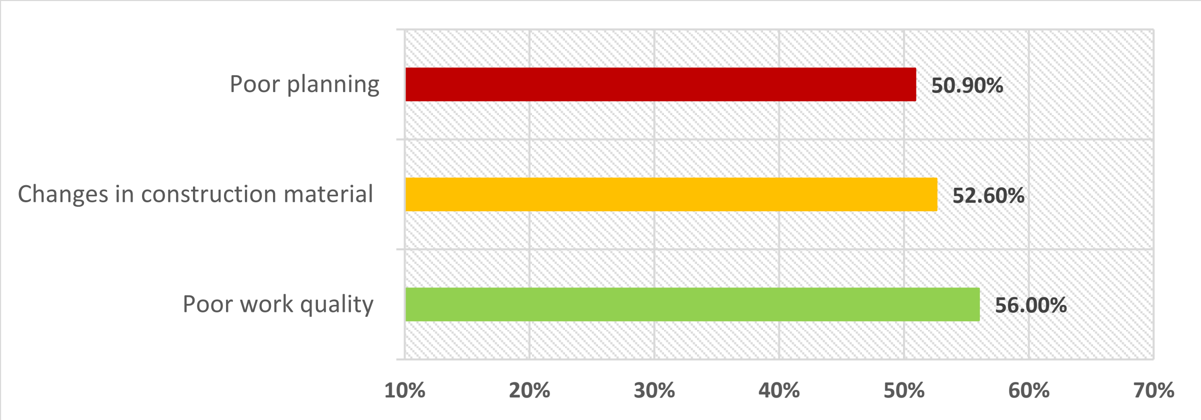


Figure 7.5: Respondents perspective on poor planning and quality and changes in construction materials.

Analysis from the returned questionnaire shows that 56.0 per cent of the respondents agreed that building code amendments may result in poor quality of work, considering that the training following building code changes are not enough to understand all the changes in the code requirements. While 52.60 per cent of the respondents, to an extent, agreed that both the construction industry and the regulatory building officials engage in poor planning with regards to the aftermath of building code amendments, leading to the unintended consequences in the building code. Similarly, the responses from the participants indicate that 50.90 per cent of the respondents are of the opinion that building code amendments, in some cases, change the construction materials.

Heijden (2016) stressed the effects of poor planning in building code governance as it affects all area of the building regulatory system. Changes in construction material as a result of building code amendment can affect the building durability and quality of work, especially when the material users do not possess adequate knowledge (Ian Page & Greta Gordon, 2017; Jishnu Kumar Subedi, 2008; Lee Neil et al., 2008). The findings in this study are in line with the previous research conducted by (Khan Raza Ali et al., 2010) regarding the impact of code amendment on construction materials. Based on the survey respondents believe, the findings suggest that poor planning following building code amendments affects the quality of design, construction and unnecessary changes in the construction materials. Furthermore, the study is of the view that poor planning has the tendency of resulting in poor work quality, particularly where additional knowledge may be required to implement the changes in the building provisions. The study findings on poor planning could be as a result of unpreparedness to contain the unforeseen effects of building code amendments. Hence, a systematic planning approach, followed with an action plan, should be strictly adhered before, during and after building code amendment. The approach will contribute to reducing the impact of unintended consequences of building code amendment.

The analysed questionnaire shows an aggregated mean value (M = 3.65) and a standard deviation value (SD = 0.99) that implies that poor planning, quality and changes in construction materials have the potentials that can adversely affect the benefits and purpose of building code amendments in New Zealand. Findings from the Friedman test (P = 0.287 < 0.05) indicates that the null hypothesis should be rejected, as shown in Table 7.6.

Table 7.6: Friedman test results for poor planning and quality and changes in construction materials.

Friedman test results	
	Mean rank
E1	1.93
E2	1.99
E3	2.08
	Test statistics

N	116
Chi-Square	2.496
df	2
Asymptotic significance	.287

N = Number of respondents, df = degree of freedom

7.4.6. Regulatory deficiency within the authorities

Following the quest to identify and reduce the unintended consequences resulting from building code amendment in New Zealand, the questionnaire respondents were asked to evaluate to what extent the regulatory deficiencies within the regulating authorities have affected the use of building code, standard and compliance documents, as illustrated in Figure 7.6.

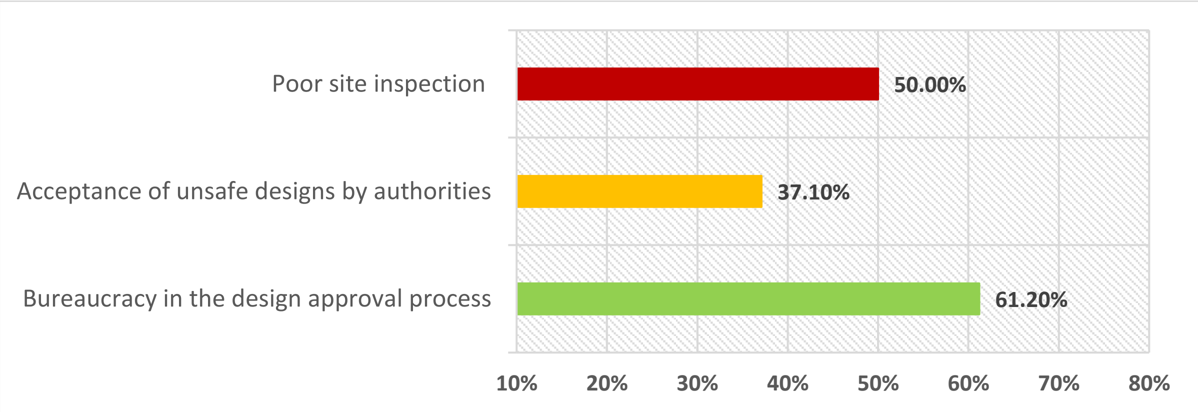


Figure 7.6: Respondents perspective on regulatory deficiency within the building code authorities.

Some of the survey participants (61.20 per cent) have the perception that bureaucracy in the administrative building regulatory system, such as in the design and construction approval process, could cause non-compliance by reducing the interest of code users in complying with the new changes in the building code requirements. Bureaucracy in building a regulatory system is a global challenge that has contributed to cost increment in code practice (John Bleasby, 2019).

Emphasised the need to simplify bureaucracy in building code (Gross, 1979), as it delays design approval and increases cost (May, 2005; Whanganui Chronicle, 2017). The high proportion of survey respondents that viewed bureaucracy in the building code system as a challenge suggests that bureaucracy have the tendency of forcing code users to involve in an illegal practice to bypass the unnecessary bureaucratic measures, thereby leading to unintended consequences of building code amendment.

Moreover, a total of 50.0 per cent of the respondents agreed to an extent, considered the level of site inspection as weak and inadequate as there may be delays before site inspection for approval is scheduled. The increase in construction activities and shortage of technical building officials in New Zealand contributed to the delay in inspection (Lois Cairns, 2015). Simon Maude (2017) highlighted the circumstances that cause inspection delay as bad weather and traffic in inspection booking, as stressed by the Auckland Council building control general manager Ian McCormick. However, (Lois Cairns, 2015; Martin, 2005) noted that some of the inspection failures are caused by builders premature request of the inspection date and builders unpreparedness for inspection. Furthermore, the delay are also capital intensive and time consuming on the part of the contractors and builders (Simon Maude, 2017). Based on the finding in this research, the study recommends a strict pre-inspection booking checklist to ensure that all bookings meet the required standard before inspection and consequences for regular offenders. Also, the study findings suggest hiring of skilled technical staff and periodic training to ensure that quality services are delivered at all times.

Regarding acceptance of unsafe designs by the regulatory authorities, only 37.1 per cent of the survey respondents believe that in some cases, the building officials may have unintentionally approved designs and constructions that are not below the bench line. The results from this study are in line with the findings from (Consumer Build, 2004), regarding unsatisfactory details in approved designs and other related documents. However, this unsafe acceptance maybe as a result of the introduction of a performance-based building code that is still on the developmental level. Although, the percentage of the questionnaire participants that believed that the building authorities accept unsafe designs shows that acceptance of unsafe design is among the least factors that contribute to the unintended consequences of building code amendment in the New Zealand context. The aggregated mean value of 3.77 and a standard deviation value of 1.12 indicates that more effects are needed to eliminate the acceptance of unsafe designs and associated documents in the administration and management of building code practice in New Zealand. For the results based on regulatory deficiency within the authorities, the Friedman test ($P = 0.001 < 0.05$) indicates that the null hypothesis should be retained, as shown in Table 7.7.

Table 7.7: Friedman test results for regulatory deficiency within the building code authorities.

Friedman test results	
	Mean rank
F1	1.82
F2	1.75
F3	2.44
	Test statistics
N	116
Chi-Square	45.698
df	2
Asymptotic significance	.001

N = Number of respondents, df = degree of freedom

7.5. Conclusion

Most of the unintended consequences emerge from the complexities in the building code and the regulatory system. The level of complexity and regulatory deficiency following building code amendments demonstrates the potentials of the unintended consequences of building code amendment and the need for improvement strategies. The study investigated the impacts of unintended consequences of building code amendments in New Zealand. The unintended consequences of building code amendment examined were related to insufficient education and incompetence, cost increment, weak enforcement, inadequate technical guidelines, poor planning, and regulatory deficiency within the authorities. Based on the findings from this study, the survey respondents emphasised the necessity to reduce the unintended consequences of building code amendment in New Zealand. Findings from this study also show that most of the unintended consequences in the application of building code result from lack of proactive training, bureaucracy in the design and construction approval process, cost increase, poor implementation, shortage of technical staff and poor quality of work. The responses from the questionnaire participants also imply that poor awareness, lack of incentives, poor implementation and compliance, shortage of technical staff, increased technical complexity, inadequate technical assistance to the code users, poor planning and delay in site inspection have impacts on the unforeseen consequences following building code amendments. However, the findings indicate that, to a great extent, the code regulatory authorities do not accept unsafe design and construction. Regardless of the unintended consequences of building code amendments, there are several benefits of building code amendments.

A high proportion of the respondents firmly believed that inadequate technical guidelines unintentionally contribute to the consequences of building code amendment. The study revealed that providing satisfactory technical guidelines will immensely reduce the negative impacts of building code amendments in New Zealand. Structuring a proactive enforcement team that would comprise all the relevant stakeholders will substantially eliminate some of the unwanted consequences of updating building code while encouraging compliance culture among the code users. Furthermore, the study findings also show the necessity to minimise the bureaucracy in building code administration, especially in the design and construction approval process. In the pursuit to reduce the effects of building code amendment in New Zealand, the study recommends training of code users and building officials on implementation of the new changes to code requirements and provision of low-cost or free technical assistance to code users. Although building code policy regulators in New Zealand opens consultation with code users; however, there is a need to allow the voice of the code users to count in the amendment process.

Following the outcome of this study, the question of how to quantify the impacts of each of the identified factors contributing to the unintended consequences of building code becomes necessary. Besides, there were concerns raised on developing a framework to balance how each of the stakeholders contributes to the negative impacts of building code amendments. Moreover, based on the findings from this research, the study recommends a follow-up study to weigh the balance between the financial implications of reducing the identified consequences of code amendment and the expected benefits of improving the consequences of updating building code. Accordingly, there is a need to quantify the extra cost incurred in amending and implementing the changes in the building code requirements. As a limitation, these study findings were not compared with other studies beyond the construction management field. This study used a questionnaire survey as the method of data collection; future research should consider using other forms of data collection in similar research.

The above questions would be addressed in the future study. Therefore, the discoveries made in this study should serve as a benchmark study on the unintentional side effect of amending building code. A better understanding and the quest to improve on the identified unforeseen consequences of building code amendment would help to eliminate the inadvertent effects of updating building code while increasing the benefits of code amendment. The findings in this study are relevant in any country and maybe applicable globally were (i) performance-based building code is applicable; (ii) the performance-based building code is regularly amended within the intervals similar to New Zealand; (iii) allows for a similar level of innovative practice when complying with the building code requirements.

8. Challenges facing building code compliance in New Zealand

This chapter was developed from Publication № 7, which has been published under the International Journal of Construction Management. 10.1080/15623599.2020.1801336. This chapter aims to answer the research question RQ4 and research objective RO7.

Abstract

Ensuring resilience in New Zealand built environment requires regular building code amendments. These amendments have caused some shortfall in complying with the changes. The compliance problems have limited the usefulness of building regulations in the country. This study aims to investigate and explore the challenges facing compliance with the building code amendments and how compliance could be improved. A closed-ended questionnaire was administered to the relevant stakeholders in the building industry to seek their individual opinions on the challenges facing compliance with the changes made to the building code. Some of the challenges considered in this study are within the areas of inadequate compliance features, organisational factors, lack of technical training and assistance, lack of building code enforcement, unforeseen consequences of building code amendment and inadequate awareness following building code changes. This study identified some of the challenges facing compliance with building code. The

findings in this study reported a high level of respondents that agreed that complexities in the building code, lack of capacity building among the relevant stakeholder, lack of training need assessment, irregular building code update and lack of awareness. However, the study reported a low proportion of corruption, showing that corruption is not an issue in the New Zealand building control system. Improvement in the training of building code users on how to comply with the changes made to the building code should be considered in future amendment.

8.1. Introduction

Existing literature shows that many building code users do not comply with the building code regulations (Burby, May, et al., 1998), despite been drafted and enacted into law to ensure building performance (Visscher & Meijer, 2007; Windapo & Cattell, 2010). Non-compliance with the building regulation is a global issue that may have attracted little or no attention (Burby & May, 2000; Burby, May, et al., 1998), and in some instance, it is neither undocumented nor documented but not reliable (Windapo & Cattell, 2010). In many cases, non-compliance tends to threaten the resilience of the built environment (Burby & May, 2000), especially in areas that are prone to active seismic activities, such as New Zealand. In New Zealand, the situation looks unique as the country has a well-developed building code and responds to seismic activities through regular building code amendments and the improvement of innovative methods in the building control system. Complying with such amended building code requirements under this condition may become challenging, as Burby, May, et al. (1998) acknowledged that there could be difficulties in code compliance.

Furthermore, compliance with building code has faced many obstacles in terms of implementation, especially where the regulatory officials lack adequate training and technical experience to assess the compliance requirements (Burby & May, 2000; Burby, May, et al., 1998; Meres, Sigmon, DeWein, Garrett, & Brown, 2012; Nwadike, Wilkinson, & Clifton, 2019c; Spence, 2004). In some cases, deficiencies in building code (Egbelakin, Yakubu, & Bowden, 2018; Gülkan, 2001; Johnson et al., 2000) may have caused complexities in building code compliance (Ang, Groosman, & Scholten, 2005; Baiche, Walliman, & Ogden, 2006; Van der Heijden & De Jong, 2009). Hence, the shortcomings in complying with the building code requirements need consideration as its consequences could bring unexpected loss to the built environment.

In the above context, the study explored and discussed the primary factors challenging building code compliance and the impact of the significant difference each of the factors has on challenges facing compliance in New Zealand. A closed-ended questionnaire was conducted within the relevant stakeholders involved in the building and construction industry and building code regulatory agencies. The outcome of this study offers an in-depth understanding of the level of challenges facing compliance and how the building control system could improve compliance in the New Zealand context.

8.1.1. Research objectives

i) To explore and investigate the primary factors affecting building code compliance.

ii) To check how each identified factor have impacted building code compliance

iii) To recommend how compliance can be improved.

8.2. The nexus between building code compliance and enforcement

Complying with the requirements of building code regulations are essential to ensure safety in the built environment. Achieving this safety requires a good connection between building code and enforcement. Many destructions from natural hazards are mainly a result of non-enforcement and compliance with the stipulated building regulations (Burby & May, 2000; Mistry et al., 2001; Thiruppugazh, 2008; Yates, 2002b). The catastrophic destruction from the 1999 Turkey earthquake and the 2001 India earthquake has been reported as enforcement and compliance failure with the building code requirements (Yates, 2002b). It is evident that a well-designed building regulatory system may not guarantee compliance with the building code (Yates, 2002b); hence, the necessity of enforcing building code to achieve compliance. Enforcement is used as a medium of compelling compliance practice with building code within the building and construction industry (May, 2004). Building code enforcement spreads across all sectors of the building and construction industry, including the local, state and central (Nwadike et al., 2019c). Burby and May (2000) pointed out that non-compliance with the building code requirement is a national issue in the United States of America.

The connection between building code amendment and compliance with these changes depends on the level of enforcement. Burby and May (2000) noted that enforcing building code requirements help to reduce the impact of an earthquake, hence, called for more concrete steps towards achieving code enforcement. Effective enforcement of building regulations is a step in the right direction (Kandel, 2007), as many buildings are constructed without an adequate check for compliance due to lack of enforcement (Meres et al., 2012). Egbelakin et al. (2018) noted that strict enforcement of building code requirements improves the seismic performance of buildings. Although Burby, May, et al. (1998) listed two methods of enforcement: (i) systematic application of deterrence and (ii) the use of flexibility, whichever way, enforcement of building code regulations are required to foster compliance.

Furthermore, how to enforce and comply with the intended changes should follow the process of initiating building code amendments. This measure would aid in ensuring that building code amendments are practically applicable by reducing the complexity of the code requirement and provide more technical interpretations (Windapo & Cattell, 2010). The proactive step is necessary as building code enforcement may serve as a transient vehicle that ensures a resilient built environment. However, compliance with the building code may have moved beyond total enforcement of building code requirements to a social transformation where the code users understand the significance of compliance, show a willingness to comply and develop a compliance culture (Elffers, Verboon, & Huisman, 2006; Johnson, 2011; May, 2004). Regardless of location and enforcement method, compliance can be improved through the systematic use of incentives, training for both the regulators and the regulated, punishing serial offenders and ensuring that the cost of compliance is less than the cost of non-compliance (Ahmed et al., 2018; Burby, May, et al., 1998; Kanga & Scholz, 1984; May, 2004; Meres et al., 2012; Nwadike et al., 2019c; Sparrow, 2011).

8.3. Method of satisfying New Zealand building code

Buildings are expected to comply with the building code requirements to ensure safety and a resilient built environment. There are three ways of satisfying and demonstrating compliance with the requirements of the New Zealand building code, as shown in Figure 8.1.

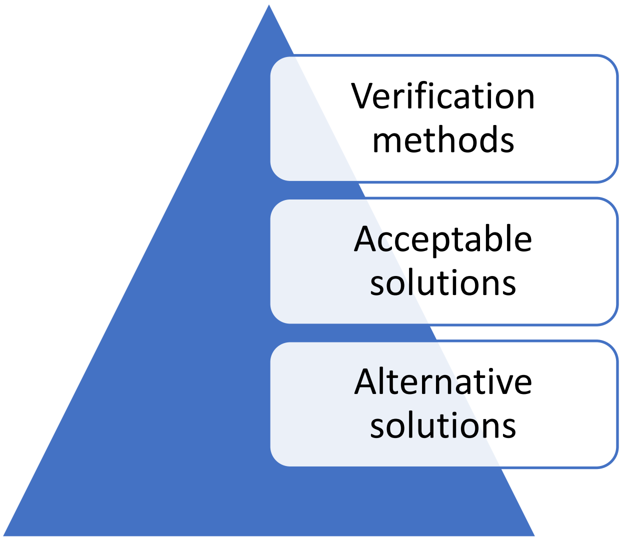


Figure 8.1: Methods of satisfying the New Zealand building code.

The compliance documents comprise verification methods and acceptable solutions. Code users can use any of the methods to fulfil the code requirements, except in situations where the building code or the building consent officers advise the use of a particular method.

The verification methods use experimental, analytical and mathematical models to satisfy the building code requirements. The experimental model includes both test-in-situ and laboratory test. The verification method is deemed to have satisfied the code requirement when it yields a positive result which must be accepted by the relevant building consent authorities (BRANZ, 2004; MBIE, 2016a). The application of the verification method as a means of compliance requires experience and competency (James, 2016).

Acceptable solutions offer precise procedures for building construction. The acceptable solution follows the prescriptive method to achieve compliance criteria deemed fit to have complied with the building code. The use of an acceptable solution as a compliance pathway may be limited and challenging to employ in the case of modifying an existing structure (BRANZ, 2004). Alternative solutions are applied mainly on complex projects and the renovation of existing structures. Alternative solutions tend to demonstrate building code compliance directly but require professional experience (MBIE, 2016b).

According to MBIE (2016b), the verification methods and the acceptable solutions are not applied to all building works. Each method of satisfying the requirements of the building code have specific areas where it may be applied. In alternative solutions, the Building Consent Authority must be carried along from the initial stage of the building works to ensure a smooth understanding of how compliance with the building code is achieved. The objective, functional and performance requirements of the 2004 Building Act must be fully demonstrated before issuing building consent (Whanganui District Council, 2010).

8.4. Research method

This study examines the challenges facing building code compliance after amendments to New Zealand. In doing so, the study identified the primary factors affecting compliance with the building code and assess to what extent these identified factors have affected building code compliance in practice. A quantitative closed-ended questionnaire method was adopted and administered to the relevant stakeholders in the building industry to seek their opinions regarding the challenges facing compliance with building code. The rationale for using a closed-ended questionnaire was because it is a cost-effective method of gathering large scale data from different stakeholders within a short duration (Russell, 2002). The closed-ended questionnaire helped to guide the respondents within the context of the research scope and to maintain consistency. However, options were provided where the respondents can give additional information considered to be relevant to the research topic.

In this study, the participants of interest include structural engineers, geotechnical engineers, architects, consulting engineers, licensed building practitioners, project managers, building contractors, local authorities, and academic/researchers. The participants were selected based on purposeful sampling techniques with criteria underpinned by their broad knowledge within the research context. Further, the purposeful sampling techniques allow research to be conducted within a setting where the survey respondents are intentionally chosen to provide relevant information within the research topic under consideration (Babbie, 2013; J. A. Maxwell, 2013; Tongco, 2007). The closed-ended questionnaire is divided into seven categories, comprising of the participant's profile, inadequate compliance features, building code enforcement, organisational factors, unforeseen consequences of building amendment, technical training and assistance and inadequate awareness. The division was to ensure that all challenges facing building code compliance are well treated.

8.4.1. Data collection and analysis

A closed-ended questionnaire technique was chosen, as it is a useful tool for cost reduction in data collection (McLeod, 2018). The questionnaire was distributed in both paper form and online through the use of the Qualtrice platform (Snow & Mann, 2013), to ensure a large scale data collection. The crux for the data collection was to address the challenges facing building code compliance, especially when there are changes to the building codes. The closed-ended questionnaire consists of six sections such as building code enforcement, organisational factors, technical training assistance, inadequate compliance features, unforeseen consequences of building amendment and inadequate awareness. The questionnaire was divided into categories to ensure that all aspect of the challenges facing building code is captured and addressed. Participants for this questionnaire survey were selected through the use of sampling techniques as it allows only the participants with an in-depth understanding of New Zealand codes to be chosen (Babbie, 2013; J. A. Maxwell, 2013; Punch, 2013). One hundred and sixteen closed-ended questionnaires were completed and returned.

The data collected from the survey were manually entered in the spreadsheet of IBM Statistical Package for the Social Sciences (SPSS) software in a tabulated format. The participant's response is coded in number form for easy identification. The entered data were carefully double-checked to eliminate any possibility of error. The tabulated data were run in SPSS using the Friedman test (Friedman, 1937), to check the significant differences each item of the questionnaire under different priority would have on the challenges confronting building code compliance in New Zealand. Also, the degree of internal consistency of each category in the questionnaire was checked using a reliability test called Cronbach alpha techniques (Tavakol & Dennick, 2011).

8.4.2. Participants information

The survey participant comprised of structural engineers (50 per cent), geotechnical engineers (9.5 per cent), architects (1.7 per cent), consulting engineers (1.7 per cent), licenced building practitioners 6.0 per cent) and project managers (12.9 per cent). Other participants include building contractors (3.4 per cent), local authorities (7.8 per cent) and academic researchers (6.9 per cent). Majority of the participants have 6 to 10 years (29.30 per cent) working experience, while only 14.7 per cent have 16 to 20 years of professional experience. This good average of working experience among the questionnaire participants shows that the majority of the participants have a significant in-depth understanding of building code practice in New Zealand. Also, 20.7 per cent of the survey respondents are in the director position, while 34.5 per cent are in a staff position. Furthermore, 38.8 per cent of the participants are from Auckland, Wellington (22.4 per cent), Churchchrist (32.8 per cent), Dunedin (1.7 per cent) and Others (4.3 per cent).

8.4.3. Questionnaire reliability check

The Cronbach alpha was used to measure the extent of the close relationship of each category in the questionnaire group. The Cronbach alpha coefficient (α) can be expressed as:

$$\alpha = \frac{K.\overline{C}}{\overline{V} + (K-1).\overline{C}} \qquad (8.1)$$

The α is the Cronbach coefficient, K is the number of questions in each category, $\overline{C}$ is the average covariance among the items in each category, and $\overline{V}$ is the average variance of the items.

For this study, the Cronbach alpha coefficient of 0.780 > 0.5 implies that there is an acceptable internal consistency among all the measured categories in the closed-ended questionnaire. Table 8.1 shows a summary of the Cronbach alpha reliability check, and Table 8.2 shows the summary item statistics.

Table 8.1: Cronbach alpha reliability check test.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized items	Number of items
0.780	0.785	24

Table 8.2: Summary item statistics.

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance
Item Means	3.935	3.181	4.388	1.207	1.379	0.078
Item Variances	1.086	0.681	1.575	0.894	2.313	0.061

8.4.4. Friedman Test

The study used the Friedman test to analyse the participant's opinion regarding compliance with the building and the associated challenges. The results of the Friedman test carried out for this study are illustrated in Table 8.3.

Table 8.3: Friedman test statistics[a]

N	116
Chi-Square	282.363
df	23
Asymptotic significance	0.001

The null hypothesis for this study would be that there will be no significant difference in each questionnaire item under different category would have on the compliance challenges. As a decision rule, the null hypothesis in this study would be retained if the significant value (p) is less than 0.05. Hence, the *p-value* for all the question items scaled under the challenges facing building code compliance ($0.001 < 0.05$) shows the statistical significance of all the measured items in the closed-ended questionnaire, and the null hypothesis should be retained.

8.5. Findings and discussions

Findings from this study highlighted the challenges facing compliance with building code as a result of regular building code amendment in New Zealand. The findings in this study are based on the perspectives of building code users and are discussed in the following subsections.

8.5.1. Inadequate compliance features

Following the regular amendments to the New Zealand building code, the questionnaire respondents were asked to rate to what extent they agree that frequent building code amendment affected compliance using some of the identified criteria. In total, 61.20 per cent of the survey respondents strongly agreed that the cost of complying with the building code had increased non-compliance as the code is regularly amended. While 57.80 per cent of the participants strongly believed that the poor compliance mindset of the building code users to some extent affected compliance with the building code practice. The research outcome is evident as many lack the understanding that compliance with the building code helps to reduce disaster risk in the built environment (Burby, May, et al., 1998; Egbelakin et al., 2018; Jones & Vasvani, 2017b). Also, 56.0 per cent of the respondents, to a greater extent, agreed that lack of incentives for the building code users that complied willingly with the requirements of the building regulation could be a source of discouragement for compliance. Furthermore, the respondents also pointed out that a poor disaster risk reduction mindset (54.3 per cent) among the building practitioners, to a large extent, hampered building code compliance, as shown in Figure 8.2. Table 8.4 and 8.5 show the summary of the Friedman test analysis regarding the mean rank and the test statistics.

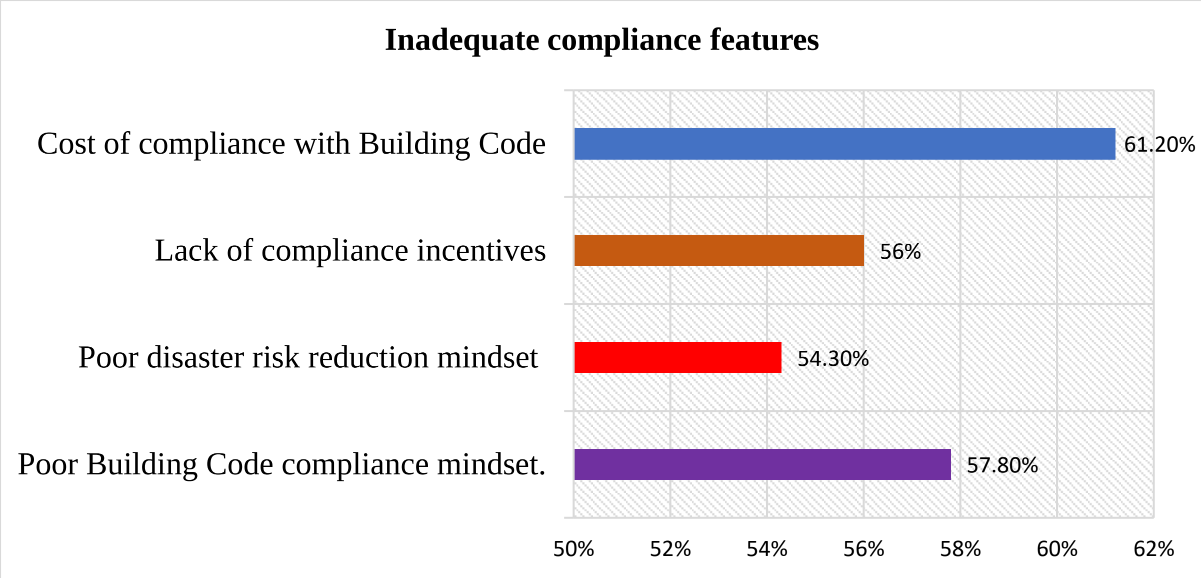


Figure 8.2: Inadequate compliance features.

Table 8.4: Friedman mean rank.

	Mean rank
Cost of compliance with building code	2.61
Lack of compliance incentives	2.52
Poor disaster risk reduction mindset	2.19
Poor building code compliance mindset	2.69

Table 8.5: Friedman's test statistics.

N	116
Chi-Square	13.553
df	3
Asymptotic significance	0.004

The opinion of the survey participants could indicate that compliance level drops following changes to the building code, as the users are yet to familiarise themselves with the new requirements. Considering the high aggregated mean value (M = 4.15) and standard deviation value (SD = 1.08), the findings from the opinion of the survey participants could indicate that compliance level drops following changes to the building code, as the users are yet to be familiar to the new requirements. Hence, there is a need for sensitisation and awareness crusade before and after building code amendment. Compliance features create an enabling environment that induces voluntary compliance among building code users. The findings suggest that inadequate provision for compliance features could contribute to non-compliance. Furthermore, the results from this study aligned with the study conducted by (Burby, May, et al., 1998), that lack of incentives to the building code users who complied willingly with the building requirements could become a barrier to compliance with the building code.

The effort to enhance compliance level can only be possible when the cost of compliance is lower compared with the cost of non-compliance (Burby, May, et al., 1998). Accordingly, the study also suggested that the cost of complying with the building code could increase following changes to the building regulations and the associated requirements. Therefore, the building code regulators and the government should consider adopting strategic measures that will ensure that the cost and punishment of non-compliance will be much higher compared to the cost of complying with the building code. However, the building code regulators should ensure that the cost of compliance will not become a barrier to the people that are willing to comply. Some building code users agreed that the cost of complying with the building regulations had become a barricade to compliance with the building requirements (Kanga & Scholz, 1984; May, 2004). Kelly (2012) advised for a reassessment of building code amendments impacts in terms of cost on the building industry and the building owners. From the outcome of Friedman's test analysis ($p = 0.004 < 0.05$), it is clear that the results imply that the null hypothesis should be retained.

8.6. Building code enforcement

To further understand how building code amendment has unintentionally affected compliance with the building code requirements, the study participants were asked to rate to what extent building code amendment have affected the enforcement of building code on a five-point Likert scale. The rationale for this question was underpinned to assess how the changes to the building codes influence enforcement and hamper compliance with the building code. The responses of the survey respondents are shown in Figure 8.3. Table 8.6 and 8.7 illustrate the summary of Friedman mean rank and the test statistics.

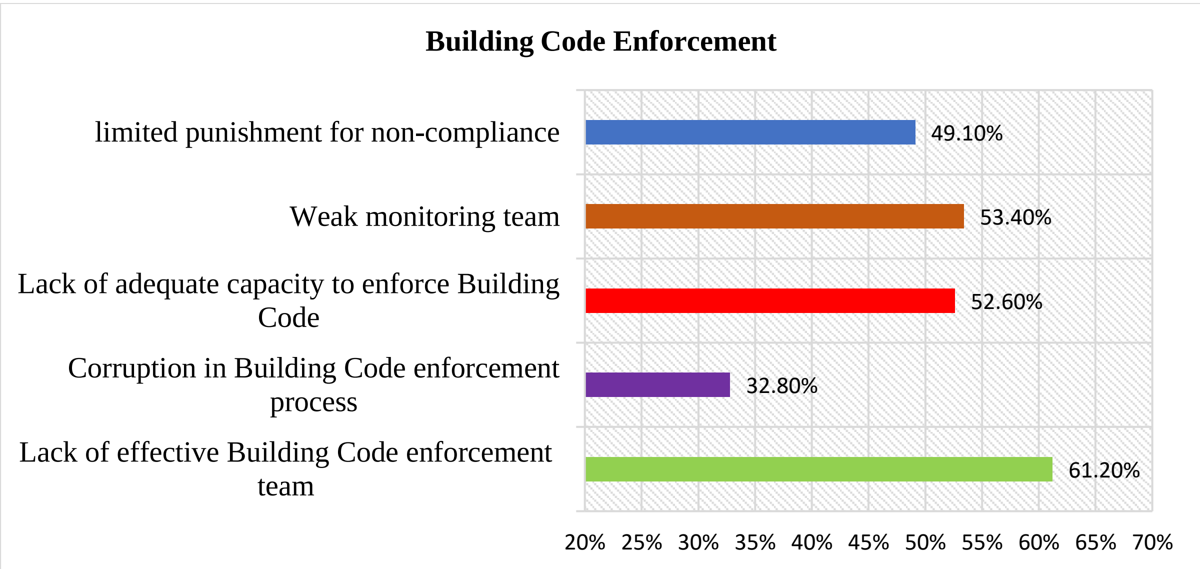


Figure 8.3: Building Code Enforcement.

Table 8.6: Friedman mean rank.

	Mean rank
Limited punishment for non-compliance	2.97
Weak monitoring team	2.95
Lack of adequate capacity to enforce building code	3.07
Corruption in building code enforcement process	2.27
Lack of effective building code enforcement team	3.74

Table 8.7: Friedman's test statistics.

N	116
Chi-Square	67.443
df	4
Asymptotic significance	0.001

A higher proportion (61.20 per cent) of the participants strongly agreed that the lack of an effective building code enforcement team affects compliance with the building code. The outcome of this study could suggest that the level of compliance with building code may depend on the effectiveness of the code enforcement team. However, about 53.40 per cent of the participants agreed that a weak monitoring team would affect the rate of compliance with the building code. Accordingly, some of the respondents (52.60 per cent), to a reasonable extent, agreed that complying with the building code could be hindered as a result of a lack of adequate capacity to enforce building code. On the other hand, 49.10 per cent of the participants believed that limited punishment for the repeated offenders for non-compliance with the building affects the level of compliance irrespective of the enforcement capacity. However, on the issue of corruption in the building code enforcement process, only 32.80 per cent of the participants are of the view that corruption influences building code enforcement and its regulatory process. From the findings, it is clear that the low proportion of the respondents that perceives corruption as an issue in the New Zealand building code system suggests that corruption is not an issue in the country.

The results from this study with a high aggregated mean and standard deviation (M = 3.75, SD = 1.10) may suggest that proactive enforcement increases compliance with the building code, especially when there are changes in the code requirements. Burby, May, et al. (1998) reported that thorough and enhanced enforcement increases compliance expectations, although more efficient when a facilitative enforcement approach is applied. Compliance with the building code requires an appropriate policy and procedures (Windapo & Cattell, 2010), regular inspection (R. Burby, P. J. May, E. E. Malizia, & J. Levine, 2000), active monitoring team (Liu et al., 2010; Windapo & Cattell, 2010; Yates, 2002b) and issuing of compliance certification (Visscher & Meijer, 2007). However, when the code requirements are practically complicated, it may cause difficulties in complying with building code requirements (Baiche et al., 2006). Furthermore, enforcing building standards help society to benefit from the advantages of building code (Yates, 2002b) while minimising the unintended consequences surrounding the use of building code. Results from Friedman's test ($p = 0.001 < 0.05$) imply that the null hypothesis should be retained.

8.6.1. Organisational factors confronting compliance with building code

Among the surveyed respondents on how organisational factors has affected building code compliance in New Zealand, 63.80 per cent of the participants agreed that lack of capacity building within the construction industry, regulatory agencies and the building code users could be a challenging issue in complying with changes made in building code regulations. Accordingly, 56.0 per cent of the participants agreed that the lack of proper stakeholders engagement during the building code amendment process contributes to the poor compliance with the building code. Although the Ministry of Business, Innovation and Employment is increasing efforts toward making compliance more accessible through the consultation process (MBIE, 2019i), the findings from this study show that more proactive steps are needed to reach the desired compliance level. A total of 52.60 per cent of the questionnaire respondents believed that the lack of collaboration among stakeholder could hinder compliance with the building regulations. Refer to Figure 8.4, Table 8.8 and 8.9 for the summary of these outcomes.

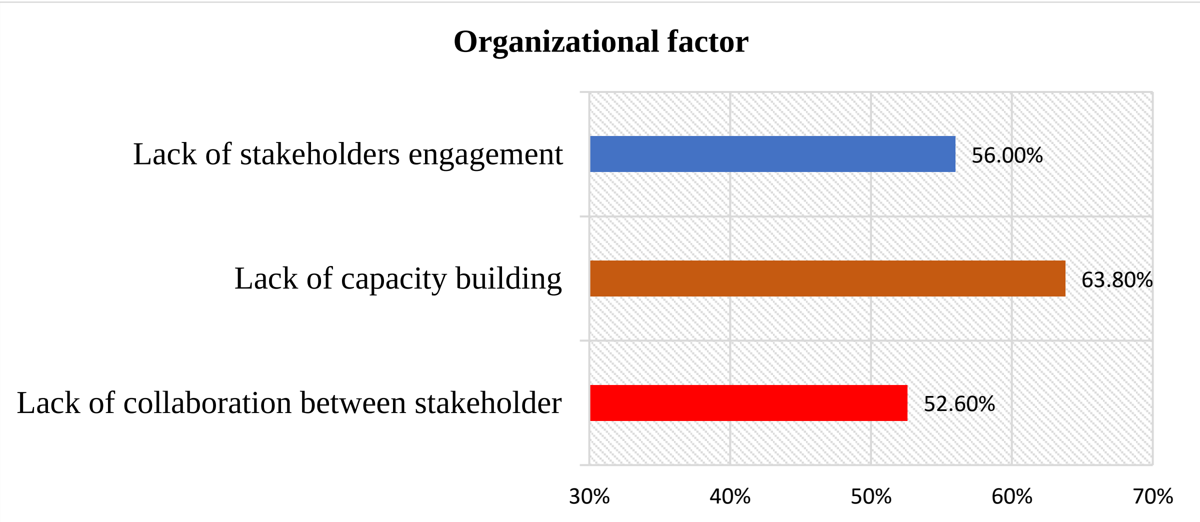


Figure 8.4: Organisational factors confronting compliance with building code.

Table 8.8: Friedman mean rank.

	Mean rank
Lack of collaboration between stakeholders	2.12
Lack of capacity building	1.93
Lack of stakeholders engagement	3.07

Table 8.9 Friedman's test statistics.

N	116
Chi-Square	4.342
df	2
Asymptotic significance	0.114

From the above findings, a high aggregated mean value (M = 3.79) and standard deviation (SD = 0.95) indicates that organisational factors affect building code compliance in New Zealand. Stakeholders consultation with a suitable environment and consistent involvement will help to harness their potentials to reduce the incidence of non-compliance with the building code (Yates, 2002b). This could be a source of encouragement to increase the corporation of the stakeholders to participate in all programmes targeting how to improve enforcement and compliance level within the building code users. Chmutina and Bosher (2015) noted that lack of capacity building among the building code user and the regulators could increase non-compliance with the building requirements. Burby, May, et al. (1998) believed that the lack of capacity building in compliance with the building code could be effectively solved through training and employment of experienced personnel into the system.

Further, York, Bastian, Relf, and Amann (2017) encourages collaboration among all relevant stakeholders, as this process would help to boost stakeholders interest in building code compliance. Collaboration could help to increase the understanding of stakeholders on changes made to the building code (Chmutina & Bosher, 2015; IRC, 2010a) and foster voluntary compliance with building regulations (Burby, May, et al., 1998). The results from the Friedman's test (p = 0.114 > 0.05) indicates that the null hypothesis should be rejected, as it may not be statistically significant (McLeod, 2019).

8.6.2. Inadequate awareness following building code compliance

Findings from Figure 6 based on the evaluation of the survey respondents on inadequate awareness of building code compliance, 57.80 per cent believed to some extent that poor awareness of the consequences of non-compliance with the building regulations could become a critical factor in building code compliance. The outcome from this study could indicate that the government and the Ministry of Business, Innovation and Employment need to employ more measures to ensure that proactive awareness proceeds any changes in the building codes and standards. Furthermore, the results from the study indicated that (56.90 per cent) poor awareness of the benefits of complying with the building code requirements could lead to non-compliance, while about 50 per cent of the participants agreed that there is a lack of concern for building code among the building code users as shown in Figure 8.5. Table 8.10 and 8.11 explain the summary of Friedman mean rank and the test statistics.

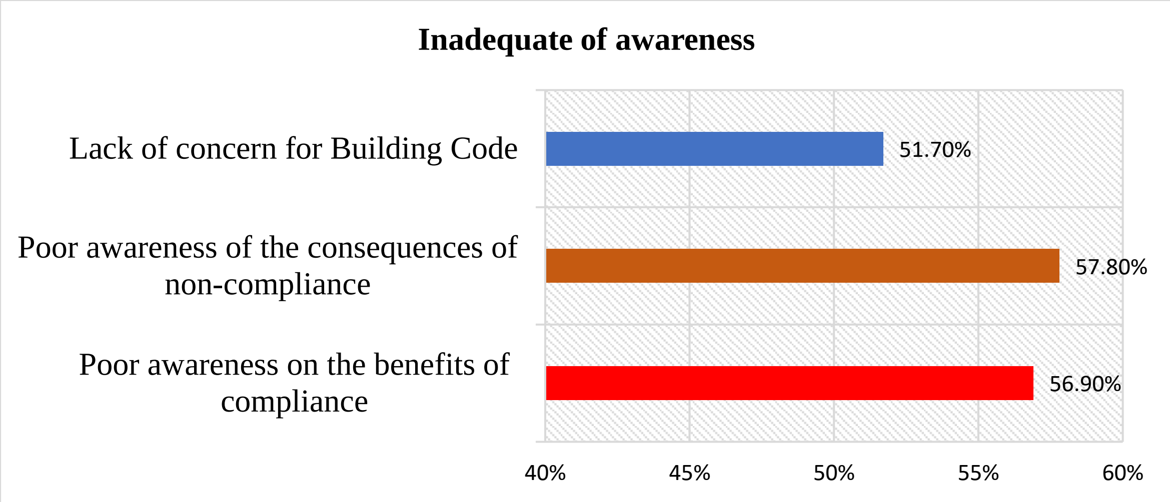


Figure 8.5: Inadequate awareness following building code compliance.

Table 8.10: Friedman mean rank.

N	116
Chi-Square	1.415
df	2
Asymptotic significance	0.493

Table 8.11: Friedman's test statistics.

	Mean rank
Poor understanding of building code compliance documents	2.50
Lack of qualified technical staff	2.28
No training needs assessment	2.91
Poor training for code users	2.32

The survey participants rated all the criteria under inadequate awareness above 50 per cent, showing the necessities of educating the building code users on the advantages attached to code compliance. The cumulative mean value of 3.87 and the standard deviation of 0.90 showcased that awareness is needed to increase compliance with the building code. The findings from the Friedman's test (p = 0.491 > 0.05) shows that the null hypothesis should be rejected.

The high percentage of participants that sees awareness as a critical factor in complying with building code requirements was not a surprise because the New Zealand building code undergoes a bi-annual amendment process at a regular interval. Hence, this could mount pressure on the code users to look out for new updates and learn various ways to comply with the requirements. The findings in this study are in line with the previous study by (Mannakkara & Wilkinson, 2013) that non-compliance to the regulations are a result of a lack of awareness and inadequate understanding of the new legislation. Duncan (2005) acknowledged that it was a significant mistake as the New Zealand building code amendment in 1992 was not accompanied with adequate awareness and systematic training on how to comply with the new amendments, as the building code was shifted from prescriptive to performance-based building code. The present study also aligned with the findings from (Windapo & Cattell, 2010) regarding the unwillingness of building code users towards complying with the building code requirements. Some building code users do not care to comply with the building regulations (Kanga & Scholz, 1984), especially where there are no effective enforcement and due punishment for offenders.

8.6.3. Technical training and assistance to the building code users

The questionnaire survey outcome in this study shows that technical training and assistance to the building code users are among the pressing challenges that encourage non-compliance, with all the criteria scoring above 50 per cent. In total, 55.20 per cent of the questionnaire participants agreed that poor understanding of the building code amendments and standards would promote non-compliance. Also, the respondents agreed that lack of qualified technical staff on the part of the building code regulators could significantly contribute to non-compliance and discourage the building code users (60.30 per cent). In addressing the issue of training following building code amendment, 50.90 per cent of the survey respondents believed that there is inadequate training for the building code users, while 60.90 per cent are of the opinion that inadequate training need assessment before training could lead to non-compliance.

The findings from this study with an aggregated mean value (M=3.98) and standard deviation (SD=1.03) could stress the need to offer free technical assistance and a continuous training programme for the code users to boost understanding of the code changes and increased compliance culture. Even though this procedure may be a disadvantage venture to the code regulators, however, it remains one of the best approaches to increase understanding of the building code and the associated changes that will result in reduced non-compliance. Besides, the Friedman statistical test ($p = 0.001 < 0.05$) for the training and technical assistance indicates that the null hypothesis should be retained. Figure 8.6, Table 8.12 and 8.13 demonstrates the summary of the Friedman test statistics.

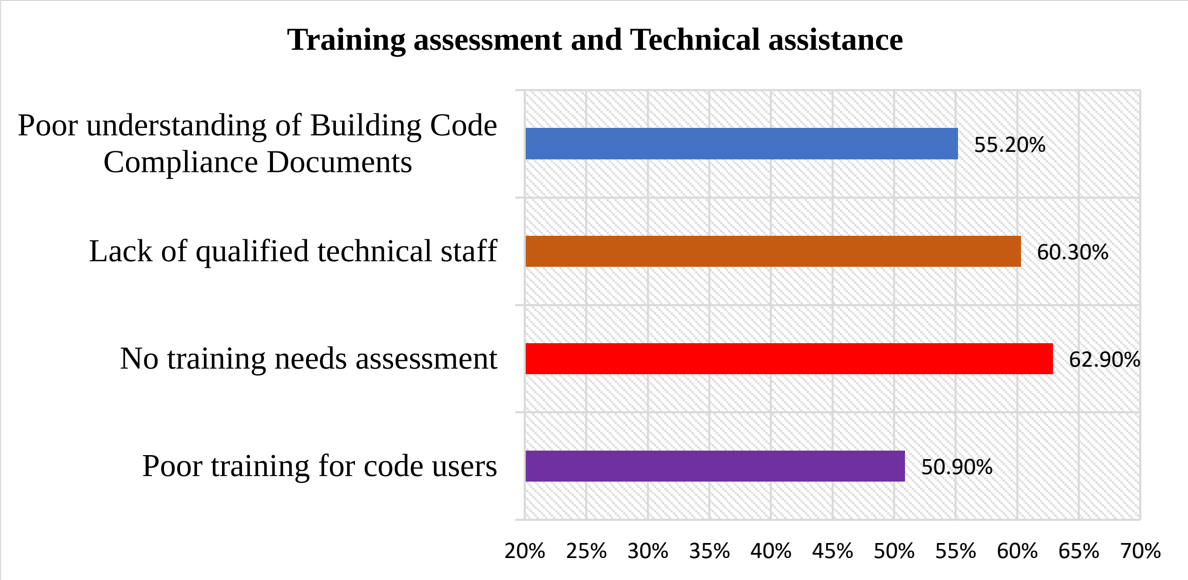


Figure 8.6: Training assessment and Technical assistance to the building code users.

Table 8.12: Friedman mean rank.

	Mean rank
Poor understanding of building code compliance documents	2.50
Lack of qualified technical staff	2.28
No training needs assessment	2.91
Poor training for code users	2.32

Table 8.13: Friedman's test statistics.

N	116
Chi-Square	24.335
df	3
Asymptotic significance	0.001

Chong and Ricciarini (2015) recommended customising the training to the building code users speciality as a measure to increase understanding and creating awareness. The lack of understanding and training on building code changes could create a knowledge gap (Burby, May, et al., 1998; Windapo &

Cattell, 2010) that would result in non-compliance. Filling these gaps becomes necessary when complying with the code changes as it may require some specific technical knowledge (Duncan, 2005; May, 2004; Van der Heijden & De Jong, 2009; Windapo & Cattell, 2010) as innovative methods and regular code updates characterise New Zealand building control system. Van der Heijden and De Jong (2009) believed that a better understanding of building code requirements creates an enabling environment for compliance. However, the success of compliance with the building regulatory practice is underpinned by the experience of the technical staff (Burby, May, et al., 1998; Van der Heijden & De Jong, 2009), who will enforce the building code and assist the code users, and this is lacking in many occasions. Hence, based on the findings from this study, both the regulators and the code users need an extensive training and understanding to achieve compliance, especially as the building code lean towards full performance-based practice.

8.6.4. Unforeseen consequences of building code amendment

The questionnaire participants for this study were asked to rate the extent they agree that building code amendment has unforeseen consequences that have unintentionally affected building code compliance in New Zealand, especially as the country regularly updates their building code. Approximately 58 per cent of the respondents strongly pointed out that long wait for work inspection has affected compliance with the building code, as shown in Figure 8.7. For the summary of the Friedman test findings, refer to Table 8.14 and 8.15.

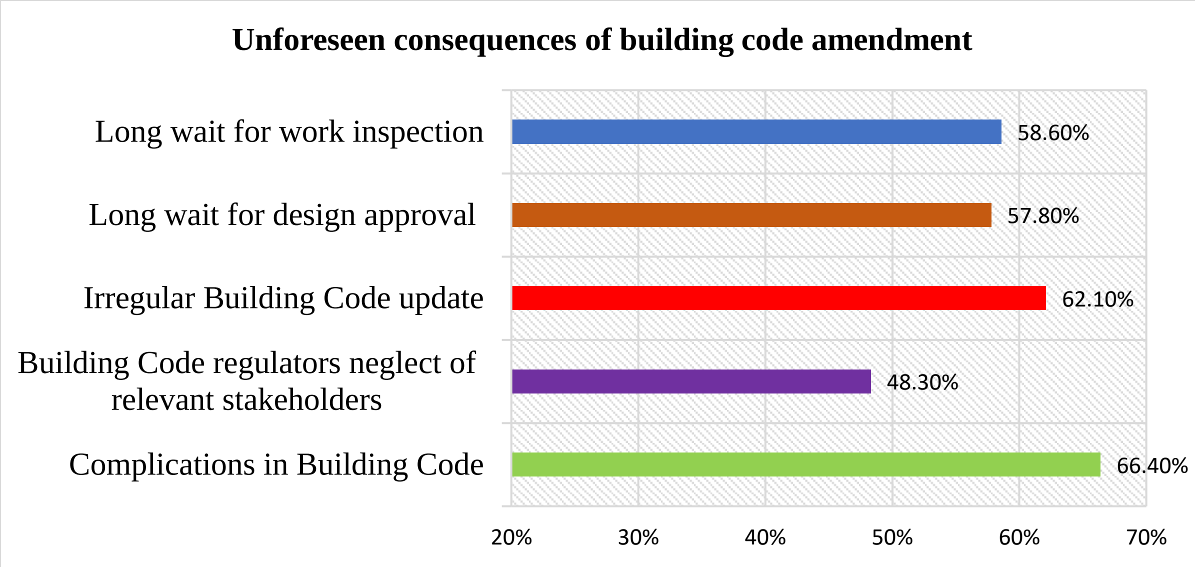


Figure 8.7: Unforeseen consequences of building code amendment.

Table 8.14: Friedman mean rank.

N	116
Chi-Square	71.980
df	4
Asymptotic significance	0.001

Table 8.15: Friedman's test statistics.

	Mean rank
Long wait for work inspection	2.45
Long wait for design approval	3.28
Irregular building code update	3.40
Building code regulator's neglect of relevant stakeholders	2.35
Complications in Building code	3.52

The long wait for work inspection could be caused by a lack of experienced building inspectors (Duncan, 2005; Smallman, 2019), who are familiar with new building code requirements and booming in the construction industry. Following the building code amendment after the 2011 earthquake in Christchurch, Cairns (2015) reported that the long wait for building inspection has almost reached a 50 per cent failure rate.

Furthermore, 57.80 per cent of the survey participants, to a great extent, believed that long wait for design approval had discouraged the code users from complying with the building code requirements. As the construction work cannot start without the design approval, it could be discouraging to wait for a long period, especially when the project start and duration is fixed (Demotte & Paciaroni, 2014). The long wait for design approval could be improved by conducting an impact assessment on the new rules before enacting them into law. The lengthy process of waiting could increase the cost of construction and labour (Williams, Eden, Ackermann, & Tait, 1995), as market value is not immune from inflation. Also, providing simplified details of building code compliance requirements will help to reduce the confusion surrounding compliance and improve the unexpected delays (Nuth & Duncan, 2019).

Accordingly, some of the survey participants (48.30 per cent) believed that neglecting the stakeholder's contribution regarding building code amendment could lead to some unforeseen consequences such as non-compliance with the code requirements. The above findings could suggest that the stakeholders fill the gap between having a simplified building code requirement and providing practical means of implementing and complying with such regulations. However, neglecting their involvement in building code adoption, amendment and implementation could result in non-compliance (Evans & Martinez, 2016). New Zealand building code regulators conduct a series of consultations with the relevant stakeholders within the industry (MBIE, 2018b); however, how effective their contributions are utilised may have influenced the research findings. The engagement of stakeholders in the building code process has helped to identify areas of public concerns and address how it may be implemented (Lawrance et al., 2014; Nuth & Duncan, 2019; Vaughan & Turner, 2013; Volha & Meredydd, 2016).

The survey participants identified irregular building code update (62.10 per cent) and complications in building code (66.40 per cent) as the primary sources of unforeseen consequences surrounding compliance with building code. The findings suggest that when there are changes in the building code without any specified interval, it could lead to complexities in implementing the code requirements. Irregular amendment of the building code creates pressure among the building code users in keeping up to the speed of the amendment process. Sedam (2015) noted that code complexities cause failure and inability to cope with building code changes. Complexities in building code increase the challenges of compliance with building code (Burby, May, et al., 1998).

Based on the findings from the study, the Friedman test ($p = 0.001 < 0.05$) indicates that the null hypothesis should be accepted. Also, the aggregated mean value of 4.03 and a standard deviation of 1.07 buttresses the need for an impact assessment to capture possible shortcomings of any changes to the existing building codes and standards.

8.7. Conclusion

The study discussed the challenges facing building code compliance in the New Zealand context. The regular building code amendment practice in New Zealand necessitated the need to investigate compliance barriers and their practicability. In identifying the building code compliance challenges, the study explored the existing literature to build the theoretical background related to building code. The study used a closed-ended questionnaire, analysed in Friedman test and validated with Cronbach alpha reliability check to access the opinions of building code users regarding barriers to building code compliance.

The findings from this study emphasised the need to improve on the challenges that hamper compliance with building code. The research presented a high proportion of participants that believed that frequent building code amendment in the study context contributes to the issue that causes non-compliance among the building code users. Further, the reliability check from the study implies that there is a high level of internal consistency among all measured criteria used in the closed-ended questionnaire.

Findings from the participant's response show that the high cost of complying with building code requirements (61.20 per cent) is a pressing barrier to building code compliance, particularly when the cost for non-compliance is less compared with the cost of compliance. As noted by May (2004), compliance cost reduction would most likely increase the habit of complying with the building regulations. Also, the lack of regulator's capacity building (63.80 per cent) and involvement of stakeholders (56 per cent) should be improved, as the survey respondents identified them as the critical challenges that cause non-compliance. While regular changes to building code are significant in the building and construction industry, some of the participants strongly pointed out that adequate technical training and assistance to the building code users enhance compliance. This can be achieved by ensuring that the building code users are given sufficient training and measurable technical assistance before any code changes are enforced.

Regarding building code enforcement, the high proportion (53.40 per cent) of respondents that considered it as an issue suggest that enforcement of building code is an essential requirement to achieve maximum compliance, irrespective of the enforcement method. Furthermore, since the New Zealand environment is prone to active seismicity, a more proactive enforcement and monitoring team is highly recommended based on this research outcome. In this situation, members of the expected active enforcement and monitoring team should be drawn from all the relent stakeholders sector. The findings from this study stressed that corruption in the building code enforcement process might not be a pressing issue; however, it calls for a more transparent process that would discourage any corrupt practice. These findings could be suggestive, considering the sample population used in this study compared to the countries population.

The research noted the need to use the opportunities offered by the regular building code amendment process to simplify the code requirements, as the building code users believed that the New Zealand building code is complex and may be difficult to achieve compliance. The study findings add to the prior literature calling for a more user-friendly building code and compliance requirements because it is easier to comply with simplified building code requirements (B. Meacham, 2010b; Norwegian Building Authority, 2016; Southland District Council, 2018; Spence, 2004). The research suggested that the building code could be simplified by providing definitions to the technical terminologies, technical assistance and raising awareness by training and educating the code users on how to achieve the code requirements and its significance in New Zealand built environment. Hence, the study has helped to illuminate the significance of building code compliance and its challenging issues. Creating awareness of the consequences of non-compliance with the building code helps to increase compliance culture. During the interaction and distribution of the closed-ended questionnaire, the issue of how to improve compliance, enforcement, and stimulates the participation of stakeholders came up; this question will be addressed in future research. The stakeholders should be actively involved at all levels with adequate capacity building in enforcing building code requirements to achieve compliance.

9. Improving resilience through effective building code compliance

This chapter was developed from Publication № 8, which has been published in the proceedings of the 2019 international i-Rec conference, Florida, United States of America. This chapter aims to answer the research question RQ4 and research objective RO8.

Abstract

The paper aims to develop a compliance framework with the building code, regulation and standards for a safer built environment. The purpose of this paper is to develop a framework that will improve and encourage effective building code compliance to achieve disaster resilience. The compliance framework aims to enhance the resilience of the built environment through an easier and practical approach to communicating and managing code requirements. The paper will examine the significant factors affecting code compliance with building code and why some parties find compliance challenging to achieve. The compliance framework to enhance building code compliance was developed from an integrative literature review and conceptual context. The paper highlighted the significant factors affecting code compliance and why some parties find compliance difficult to achieve. The paper shows the main code compliance drivers amongst stakeholders and how an effective compliance process can be achieved by multi-

party collaboration and simplification of building codes. This study has not tested the developed compliance framework. The applicability of the framework can be tested using different case studies. The developed compliance framework should be incorporated into the building code compliance process. This is original research that takes a unique look at enhancing compliance with building code, regulations and standards by developing a framework to aid easy code compliance to achieve a safe built environment.

9.1. Introduction

The built environment has witnessed many disasters over the years, caused by nature or human-made. Building code regulation has been identified as a measure to reduce the impact of a disaster such as an earthquake causing destruction to buildings and infrastructure in the human environment. Building code exists in most countries that are prone to earthquake; however, building collapse still causes deaths and economic losses during an earthquake. Deficiency in compliance with code regulations has been attributed as the primary root of large-scale deaths and property loss in recent disaster (Burby & May, 2000; Suresh V., 2002).

The disaster inspired by natural hazard reveals a lack of compliance with the building code in the built environment (Ricciarini Sylvana, 2009). Introducing and enacting building code into law is a pathway in the right direction that demands the sustainable participation of different stakeholders. Some of the countries in Asia, such as Bangladesh and Nepal that have building code lacks the compliance application in reducing disaster (Ahmed et al., 2018). Non-adherence to compliance culture has been attributed to the low-income countries, which

(Moullier & Krimgold, 2015) described that compliance criteria's in those countries are too high because of over-dependency on imported building materials. In many low-income countries, there is no integration among the major stakeholders involved in the building industry, which account for significant challenges facing enforcement and compliance (Moullier & Krimgold, 2015).

The benefits of building regulations in addressing the issue of disaster cannot be achieved without making the compliance documents of standards, codes and regulations to be user-friendly, easy to understand and a well-defined pathway to earn compliance. A made-easy procedure of compliance documents is necessary for rebuilding cities in the post-disaster reconstruction process.

This paper presents a unique conceptual compliance framework to achieve a safer built environment through providing a practical approach that will bridge the communication gap among the stakeholders, examine significant factors affecting code compliance, difficulties in achieving compliance criteria's, and outlined an effective compliance process that will drive resilience improved built environment. Moreover, the study presents voluntary compliance strategies embedded in enforced compliance to boost compliance willingness when implementing building code requirements. In conclusion, the study emphasised the need for extensive consultation among the regulators and the regulated.

9.2. The need for building code compliance

Disaster has presented itself as a threat to the existence of humanity in the built environment. The consistent occurrence of disaster has necessitated the quest to provide solutions to reduce the impact of disaster inspired by natural hazards in the world. In pursuit of this goal, the building code has been instituted to decrease the impact of the disaster. The building code is an effective tool to protect lives and properties from earthquakes, and it reduces community risks (Ainuddin et al., 2014; Dixit Amod & Esteban Leon, 2009). Building codes are available in most countries, especially in countries prone to disaster; nevertheless, there is a significant loss to deaths and properties to disasters triggered by natural hazards as a result of building code non-compliance (Ainuddin & Routray, 2012; Bilham, Gaur, & Molnar, 2001; Dixit Amod & Esteban Leon, 2009; Gupta, Sinvhal, & Shankar, 2006). Jones and Vasvani (2017b) pointed out that enforcement of building code to achieve compliance in many countries is a significant challenge. Many low-income countries that seek to attract investors for rapid global growth do not allow strict enforcement of the building regulation acts (Spence, 2004). However, non-compliance to building codes and standards tend to limit the aim of building code as a measure that sets the minimum guidelines for any building. Building code practice can act as a source of disaster risk reduction only when adequate care and priority is given to code compliance with proactive enforcement.

Non-adherence to building standard is a global issue that has frequently shown up in the aftermath of most disaster events. This issue demands a rapid collective effort of all stakeholders to ensure that code enforcement will move beyond forcing people to comply to voluntary compliance. Furthermore, it essential to understand that building damage during an earthquake is inversely proportional to appropriate building code compliance, quality of construction material, quality of design and construction, monitoring and inspection of the building during and after construction and willingness to regular compliance without policing enforcement.

Building code provides the minimum standards for the structural safety of the building, but this can be fulfilled through effective implementation and compliance with the code. Ainuddin et al. (2014) noted that poor compliance with the building code and inadequate construction practice exposes people to earthquake vulnerabilities. In 1992, a quarter of the total insured losses was attributed to constructions that did not follow the code standards during Hurricane Andrew by the insurance industry (Conners, 1995). Glenn McGillivray (2017) claimed that 25% loss from Hurricane Andrew might have been prevented through strict code enforcement and compliance. Furthermore, the impact of the Northridge earthquake would have been reduced if the building code was adhered to strictly (Burby, French, & Nelson, 1998; CSSC, 1995). The catastrophic nature of the Gujarat earthquake was accredited to non-compliance and inadequacy for seismic safety regarding the building codes (Jones & Vasvani, 2017b; Menum C. & Mistry R., 2001; Mistry et al., 2001; Sudhir Jain, William Lettis, Murty C.V.R, & Jean-Pierre Bardet, 2002), while lack of building code enforcement and regulation was also mentioned (Yates, 2002b). In countries like Nepal, building standards have started gaining more consideration after about 250000 buildings were destroyed by the 2015 earthquake (Chitraker Navesh, 2015). Most recent disasters in Bangladesh and Nepal are significantly attributed to non-compliance to the building code (Ahmed et al., 2018). Scott Jason (2013) pointed out that it will cost the government of New Zealand $NZ 40 billion ($34 billion) to rebuilding Christchurch, following the February 2011 earthquake that claimed 185 people lives. Negligence to building code compliance is the primary difference between the impact of 7.0 magnitude earthquake in New Zealand and Haiti, where the manageable earthquake hazard in New Zealand turned into a catastrophic disaster in Haiti(Ambraseys & Bilham, 2011; Hayes et al., 2010; Lindell, 2010).

It is clear that having building code without better enforcement and compliance, losses to disasters like an earthquake cannot be reduced. Poor compliance with the building code, low preparedness and poor construction practice caused the demolition of ninety per cent of buildings in Baluchistan (Ainuddin et al., 2014). Urban vulnerability is increasing with the construction of buildings that do not comply with the standards stipulated in the building code, especially (Quarantelli, 2003) as population density and assets increases in the urban areas.

The magnitude of disaster impact in any location is inversely proportional to the level of commitment to building code amendment, implementation, and compliance practised in that area. Effective compliance with building regulations has yielded a good result in disaster prevention and reduction of damages in the built environment. Maki and Hayashi (2000) stated that the rate of building collapse in Japan had been lowered significantly through regular codes amendment, enforcement and compliance. The minimal destruction from the Darfield earthquake in 2010 showed how strict implementation and compliance to building regulations could help to reduce the impact of any disaster in the built environment (Gledhill et al., 2010; GNS, 2010). Better implementation of building code has helped in reducing the earthquake fatality nature in the last decades (Scawthorn, 2011). After the severe earthquakes in 2013 and 2015 in Nepal and Bangladesh, Ahmed et al. (2018) and Subedi and Mishima (2008) reported an increasing culture of voluntary building code compliance within the municipalities and real estate developers. Existing design methods and building construction in Nepal was changed and improved following the destruction of the 1988 earthquake (Parajuli et al., 2000). The September 16, 2015 earthquake in Chile, considered the world strongest earthquake produced only 13 fatalities, showcased the country's strict building code enforcement that requires all structures to survive a magnitude of 9 Mw earthquake without collapse (Nyachhyon, 2017). Spence (2004) highlighted that thorough implementation and application of building code have successfully reduced disaster in the built environment.

The need for building code compliance effort may fail due to lack of awareness creation to the code users, especially with the local communities, and lack of skilful technical staff with experience on how to let the code users see the importance of complying with new regulations. Educating and training the communities about the inherent risks and significance of disaster-resilient structures is a step in the right direction towards achieving a compliance mindset among the code users. However, to achieve the need for a compliance mindset among the code users and local communities, efforts must be made to let the code users see the consequences of not complying with the building code. Building code compliance is one of the vehicles to drive the goals of the disaster risk reduction agenda in the built environment. The effectiveness of code compliance and enforcement mostly dependent on the commitment of each stakeholder in carrying out their respective tasks to ensure voluntary participation of all code users at all stages of design and construction. Furthermore, all stakeholders must be involved to ensure adequate compliance with building code by setting out workable strategies to encourage local communities and code users to comply without hesitation.

9.3. The roles of stakeholders in code compliance

It is true that building code provides the minimum standard for the structural safety of buildings, but the choice to strictly comply with the guidelines stipulated in the code is what ensures safety. Improving the resilience of the built environment during and after any disaster like an earthquake requires the participation of all stakeholders to enforce the building code and compliance documents. However, in most cases, there is disagreement among the stakeholders on what should be done to enhance building code compliance through improved enforcement (Burby, May, et al., 1998). Yates (2002b) believes that only the government cannot enforce the building code in the system. Burby and May (1999) noted that the government had made limited attempts to influence the enforcement of building code practice. When all stakeholders fail to participate, it often results in lapses in enforcing building code which leads to the poor performance of structures during a disaster. Fostering better collaboration among the various stakeholders promotes mitigation for earthquake hazard structures. However, this requires attaching incentives to compliance. Although the stakeholders play different roles, it also requires communicative efforts within the stakeholders on how to carry out a successful building code enforcement in the construction industry. Figure 9.2 shows the role of stakeholders in ensuring effective building code compliance.

Policing enforcement of building code cannot result in effective compliance without providing adequate guidance on how to meet up the compliance criteria's. Hence, the building regulators and other stakeholders must ensure that all code user understands the compliance pathways and criteria's. Moullier and Krimgold (2015) stressed that the building regulators must develop engaging strategies to foster collaboration among the code user's to discuss their opinions. The collaboration must be carried out internally and externally to achieve expected results, as shown in Figure 9.1. Internal cooperation provides a platform for code user's to share and gain experience on how to achieve code criteria leading to compliance, while the external collaboration open doors to share international ideas and knowledge, as shown in Figure 9.1. The internal collaboration will help the regulators to have direct interaction with those they regulate and finds ways to administer solutions to their complaints. Zaidi Mohd Azian (2010) pointed out that lack of interaction among the major key actors in the building industry and active communication contribute to non-compliance to the building code. Moullier and Krimgold (2015) believed that open consultation gives an opportunity for stakeholders to offer views to the relevant authorities. However, in some cases, the relevant authorities neglect the views and opinions of the stakeholders and the public (Nyachhyon, 2017; Thiruppugazh, 2008).

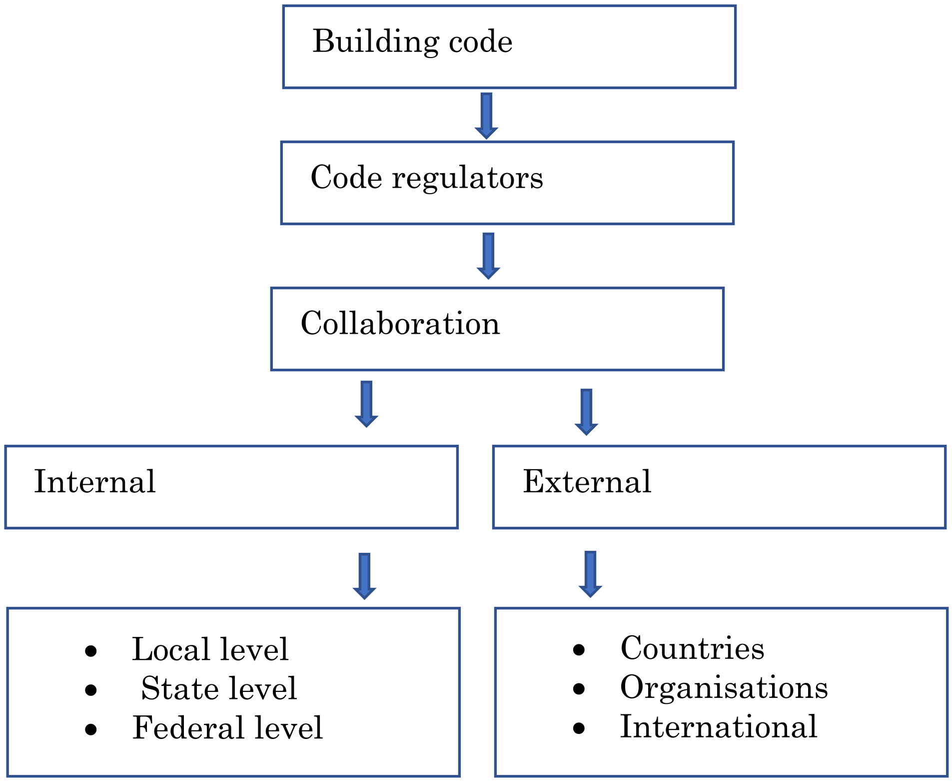


Figure 9.1: Internal and external collaboration.

Nyachhyon (2017) opined that timely dedication to the capacity building of local authorities, government, and non-government organisations would have reduced loss of lives and properties in the course of an earthquake and other extreme loading conditions. Lack of capacity building shows the weakness of building regulators and the government in fulfilling the purpose of establishing building code regulations. It is the role of the government at all levels to seek various ways of reducing seismic hazards vulnerability in the environment (Thiruppugazh, 2008). Such roles as initiating regular building code amendments, enforcement of the building code, enacting urban development bylaws, checking the strength of old buildings, an inspection of building construction and verification of building designs (Georgiou, Love, & Smith, 1999; Ilozor, Okoroh, & Egbu, 2004; Zaidi Mohd

Azian, 2010), should be giving top priority. Effective peer review of structural drawings before and during construction must be a significant factor to be considered because when the drawings are accurate, it paves the way for compliance. Nyachhyon (2017) believed that peer review of designs helps to reduce deficiency in reaching compliance. Transparency, accountability, openness and efficiency should be seen in the activities of all stakeholders towards achieving compliance.

The construction industry, the government and the building regulators, in collaboration with the professionals from the building industry, must initiate a training platform to educate the practising engineers, the technical staff of the local authorities and the entire code user community on the use of building code and various ways of achieving compliance. In most cases, the general public is ignorant of building code regulations and building planning schemes of their environment (Freiku, 2003; Owusu-Mensah, 2003; Somiah, Ayarkwa, & Agyekum, 2015), which make it difficult to comply with the rules. Therefore, the general public must be educated to understand the importance of compliance with building regulations in significantly reducing the impact of a disaster and improving the safety of building occupants.

The need to improve compliance depends on the technical support skills of the building regulators and the construction industry professionals. Nyachhyon (2017) noted that an accurate interpretation of the building code aids compliance. However, this can be achieved when strict enforcement of building code specifications regarding verification of building design, an inspection of building construction and monitoring are given top priority. Although, without a proactive functioning regulatory process, the efforts of the technical staff cannot be seen. Spence (2004) stated the need for the government to step up their action on legislative enforcement of building code, knowing that (Clift, 1996) the quality of any structure depends on the magnitude at which the building meets the requirements of the building specification. Figure 9.2 shows the stakeholders role and responsibilities in achieving compliance with performance-based building code.

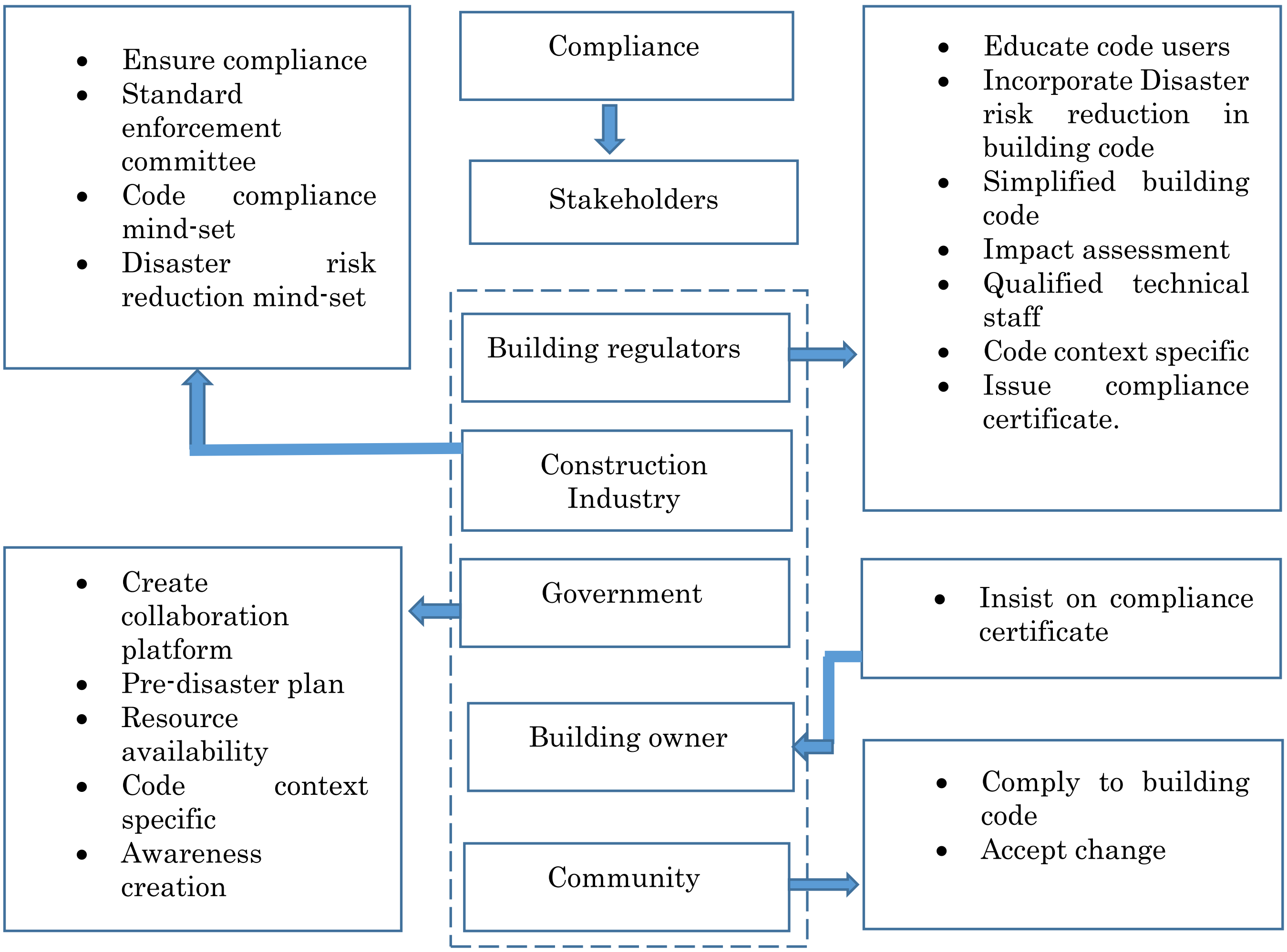


Figure 9.2: Stakeholders role in building code compliance.

9.4. Effective building regulation compliance

Building code compliance documents are written and enacted into law to be obeyed. However, research has soon that many code users do not conform to the regulations as stipulated in the building code (Burby, May, et al., 1998) even though the consequences are calamitous in the built environment. Initiating compliance culture among the stakeholders is a direction in the right path that requires proactive sensitisation and awareness creation on the need to conform to the building regulations among the stakeholders and the general public. Ricciarini Sylvana (2009) critically outlined the process to achieve effective building code enforcement procedures, which inspires compliance. Although, Dixit and Esteban (2009) stated that building code compliance documents criteria's are complicated and not understood during implementation. Although complicated building code may be safer to achieve a resilient environment, (Spence, 2004) stated that more straightforward codes are likely to be obeyed.

Effective compliance to building code demands sustainable capacity building among the enforcement agencies, the code users and the local communities. The building code compliance capacity development must be regularly assessed to identify where improvement is needed, as shown in Figure 9.3. The capacity building on the part of the enforcement agencies must ensure to provide the viable knowledge needed for careful cross-check of design drawings, monitoring and inspection during and after construction. The code users must be engaged and equipped on how to implement the building code requirements through proactive, practical oriented capacity development training. In addition, the local communities must be adequately informed about the importance of building code compliance, how to comply with the stipulated regulations and the consequences of non-compliance to their communities. However, the capacity building and the building code must be made country-specific to suit the environment where it will be applied. Bolger (2000) noted that the success of capacity building largely depends on the environment. Lack of capacity building and human resources are among the influencing factors that hinder building code implementation and compliance in Barbados (Chmutina & Bosher, 2015). According to Subedi and Mishima (2008), capacity building should be able to include and address technical, financial and resource capacity. Figure 9.3 shows the modified capacity building process for building code compliance.

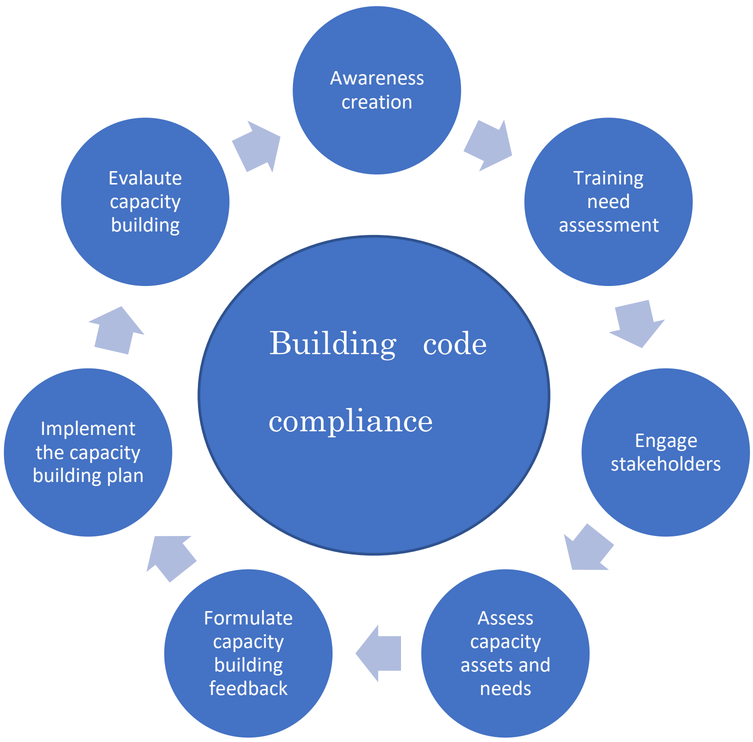


Figure 9.3: Modified Capacity building process for building code compliance (UNDP, 2008).

Building code compliance is directly proportional to capacity building, depending on the willingness of the involved stakeholders to accept changes and challenges associated with innovation. Awareness creation paves the road map to showcase the importance of conforming to building regulation, while the training need assessment will help to identify areas where adequate attention is needed. According to Kandel (2007) and Subedi and Mishima (2008), awareness creation is the initial measure towards attaining building code implementation and compliance. Furthermore, the local communities and the regulated must be informed of the vulnerabilities of hazards in their environment to disaster and the dangers of non-compliance to building code (Suresh V., 2002). Chmutina and Bosher (2015) opined that people lack understanding of the significant role of building code compliance in the safety of their environment.

9.5. Building code enforcement

Effectuating the primary aim of building code regarding compliance requires both dynamic enforced and voluntary orientated strategies. The enforced compliance approach demands consistent surveillance and a more technically skilled enforcement task-force team while providing incentives that will persuade the building code users to attain compliance voluntarily. Some of these incentives can come as wavers to building permit fees and reduction in other related fees.

Although there has not been any generally accepted method of fostering voluntary compliance (Burby, May, et al., 1998), this study offers a broad strategy to improve voluntary compliance. This study suggests a mixed-method where voluntary enforcement can only be achieved through an efficient enforced compliance approach, which will, in the long run, create the willingness to comply, as shown in Figure 9.4. The willingness to compliance will be driven when the penalty for non-compliance is much higher than the advantages of non-compliance. The long practice of strict enforcement of building code compliance creates a culture of voluntary compliance. However, adequate efforts should be made to train the code users, regulating agencies and the local communities to ensure a clear understanding of the building code requirements (Burby, May, et al., 1998). Kagan and Scholz (1980) believed that ignorance of regulations and incompetence are among the reasons for violation. Jones and Vasvani (2017b) believed that a well-informed society regarding the level of risk and vulnerability have a higher tendency to comply with codes and pay for a safer environment. Figure 9.4 shows how mixed method of compliance with the building code.

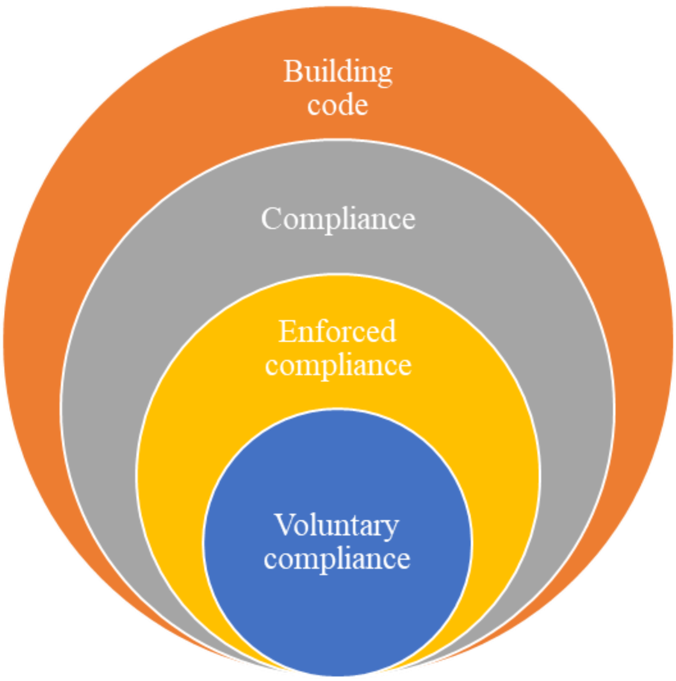


Figure 9.4: Fostering compliance approach with the mixed method.

Proactive steps in educating the building code stakeholders, offering incentives, reducing the cost of compliance and pronounced punishment for repeated offenders foster voluntary compliance, as shown in Figure 9.5. Punishment only does not achieve compliance (Moullier & Krimgold, 2015), but putting correction measures and implementing features of voluntary compliance does. Burby, May, et al. (1998) and Burby and May (2000) believes that the lack of capacity of the regulator's staff to detect violations and enforce compliance encourages non-compliance.

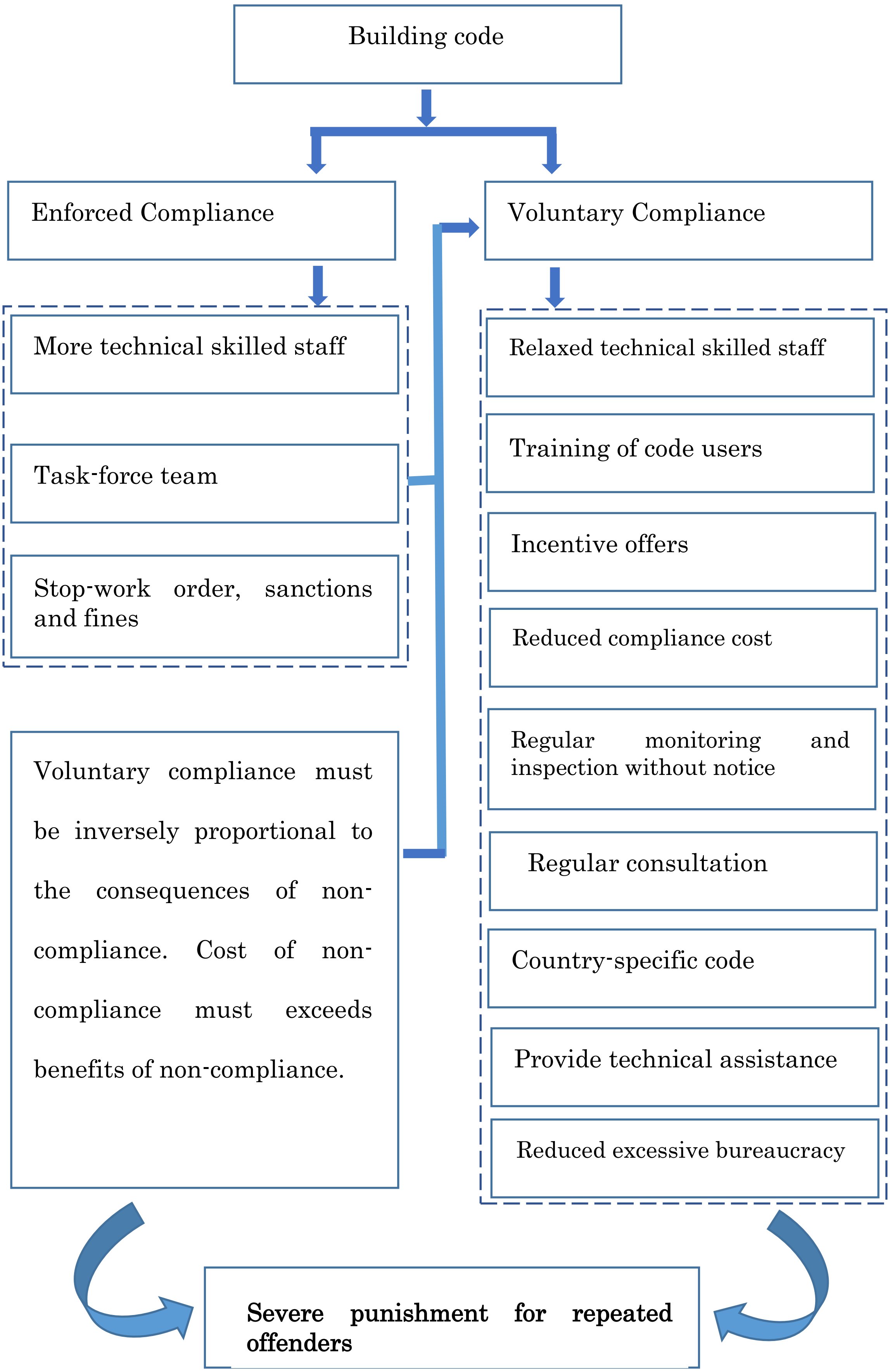


Figure 9.5: Features of Building code voluntary compliance.

Balanced enforced compliance with proactive support of voluntary compliance features in Figure 9.5 and compliance drivers in Figure 9.6 will foster a sustainable willingness to voluntary compliance within a short period if adequately implemented. Voluntary compliance can be achieved when the regulated have to trust in the regulators (Moullier & Krimgold, 2015), on the platform of drivers of voluntary compliance. However, after the active implementation of Figure 9.5 and 9.6, repeated offenders should be severely punished to deter others from violating the aims of the building code. Chong (2013b) strongly recommended that an open and transparent process will be imperative support in building code development, implementation, enforcement and compliance.

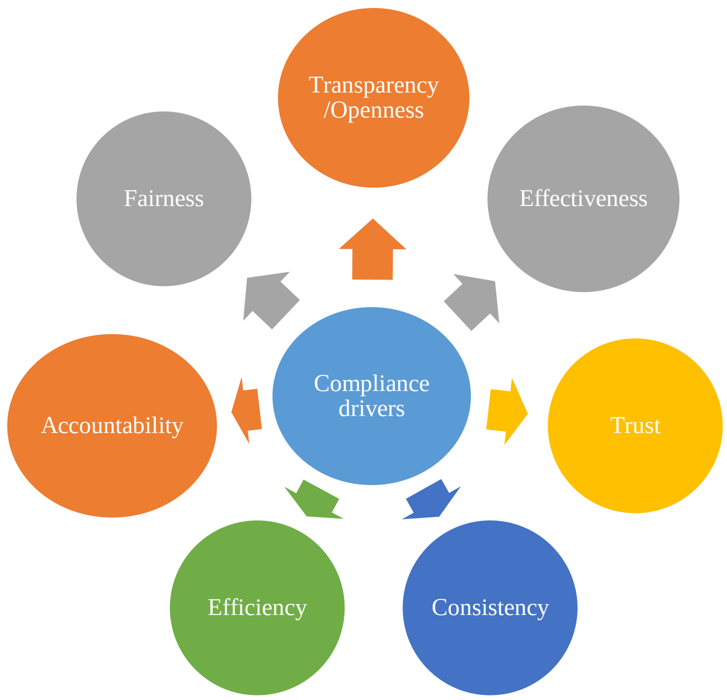


Figure 9.6: Drivers of Building code voluntary compliance.

9.6. Factors affecting building code compliance

Building code compliance is of high-level importance in the construction industry as a result of efforts made to improve the resilience of buildings in the built environment. However, adherence to building regulations has turned out to be a significant challenge to the construction industry and other stakeholders. The efforts made by all stakeholders seems not to be effective and efficient in many countries since the aims of building code have not been achieved in a wider scope. The factors affecting compliance with building code are always evident whenever there is an earthquake strike in the built environment. The issue of compliance with the building code never comes to the table of discussion except after an earthquake occurrence or other related extreme loading conditions. Ahmed et al. (2018) reported that enforcement and compliance with the building code gained attention in Nepal after the catastrophic destruction of 2015 earthquake. The Bangladesh National Building Code (BNBC) was amended with efforts to enforce the new regulations (HBRI, 2015), following the 2013 building collapse of the Rana Plaza garment factory 2013 (BHRRC, 2013).

9.6.1. The unrealistic financial impact on compliance measures

Building code regulation in many countries is dysfunctional regarding compliance. In some countries, it is unrealistic to comply with the code regulations due to (Moullier, 2014; Moullier & Krimgold, 2015) cost of construction materials and unavailability of the materials within reach of the people. According to Glenn and Wolfe (1996) and Mohammed (1997), 75 per cent cannot afford the cost of erecting a building in line with the building regulation in the Caribbean. Cost of construction material and the associated inaccessibility of the material leads to poor quality of material and construction (Goel R. K., 2003; Sudhir Jain et al., 2002).

9.6.2. Corruption in building code enforcement process

Corruption among the enforcement agencies has turned many hazards into a disaster that leads to the loss of lives and properties. Moullier (2014) noted that corruption in implementing, enforcement, verification and inspection played a major role in the Turkey 1999 earthquake, killing 17000 people. Analysis from Sedlenieks Klavs (2004) revealed that corruption and dishonesty of regulatory officials in giving building permit and enforcement discourages the subjects from complying with the building code. In some countries, it is much easier to bribe the regulatory officials than to comply with the provisions in the building codes (Krimgold, 2011); even when regulated tried to comply, the regulatory officials frustrate their efforts. Weinstein (2008) demonstrated that affiliation of code users, building owners and the regulators with the political parties play an important role in frustrating building regulation compliance in Mumbai, India.

9.6.3. Non-country-specific building code

Many low-income countries use building codes that are mainly adopted from western countries without streamlining it to suit their respective countries. Inadequate consultation of stakeholders, including the local communities before borrowing foreign building code, has enhanced non-conformity with the building code and suffocate local technology. In most cases, building code borrowing does not recognise the traditional technology of the local communities, which leads to the fear of losing cultural heritage. Furthermore, Spence (2004) believed that copying code from a developed country to a developing country could compromise the implementation and enforcement process due to lower technical capacities. These make the building code to be more complex, non-user-friendly and non-compliable in reality.

9.6.4. Insufficient resource for enforcement and technical skills

Effective enforcement of building code requires sufficient financial resource and adequate technical skill of the regulators. According to Burby and May (2000), better enforcement guarantees the reduction of earthquake losses. Yates (2002b) and Burby, May, et al. (1998) agreed that more violation detection strategies and the capacity to bring the violators to book are needed to effectuate compliance. This assertion holds because the offenders can only be punished if the system can detect the lapses. In some cases, there are technical skill regulators staff, but there is a deficiency in number to supervise the enforcement and compliance process.

9.6.5. Irregular update of building code and the associated compliance documents

Building code update is one of the fundamental pathways of achieving enhanced innovation and disaster risk reduction regarding resilient structures in the built environment. However, an irregular update of building code and the compliance documents can adversely affect compliance. In some countries like New Zealand, where building code amendment is done without any known interval although, adequate consultations are made. The code users have to run with the pace of catching up with any amendment, compared to countries like Australia, where building code is reviewed every three years. With this known interval, the regulated will not have to run to catch up with the updates.

9.6.6. Weak enforcement of building code

Enforcement of building code to reduce disaster has always been a problematic bottleneck on the regulator's side. Lack of enforcement of building code in Nepal, Bangladesh and other countries have discouraged the regulated to comply with the regulations (Ahmed et al., 2018; Ram, 2017; Yates, 2002b), which limits the aim and objective of building code. Deterrence has been described as a motivating factor to activate compliance in any regulatory policy (Hunter & Waterman, 1992; KaganRobert & Bardach Eugene, 1982).

9.6.7. Socio-political context

In many cases, compliance with the building code is affected by social attitude regarding risk perception, trust between the regulators and the regulated and political policies of the government. The socio-political perception moves code users away or towards compliance, depending on the extent to the regulated trust the policy-makers. Lee (2008) noted that compliance with regulation greatly depends on the socio-political construct of the people. Effective compliance with building code demands that building code regulators must live up to the expectations of the regulated and the host communities to earn their trust. In a social context, code user's reactions to comply with building code updates depend on the ability to interpret and understand the changes made to building code compliance documents. Although code user's action regarding compliance to building code can be affected by the way individuals perceive risk. However, awareness creation can help to propel people to see the importance of compliance and the devastating consequences while increasing their risk perception and trust. The attitude of the authorities increases or decreases risk perception and trust of the people (Terpstra, 2009).

9.7. Conclusion

Huge loss of lives and properties are always a result of negligence in conforming to the stipulated regulations in the codes. To achieve the aim of building code in having buildings that are resilient to the earthquake and other extreme loading conditions, compliance with building code must be given adequate attention at all levels. Better understanding among the regulators, the regulated, the government and the general public is required to enhance compliance culture through proactive implementation of drivers and features of voluntary compliance as described in Figure 9.5 and 9.6. Although the study encourages voluntary compliance, it also promotes severe punishment for repeated violators to serve as an example and deter others from the habit of non-compliance to building code. Embedding voluntary compliance into enforced compliance provides a holistic measure that will drive the designers and the entire construction industry to a state of willingness to comply. This study provided a practical approach with a modified capacity building process for building code compliance in Figure 9.3, to enhance the resilience of the built environment. However, the effectiveness of any building code is directly proportional to the positive attitude of the stakeholders regarding enforcement and compliance. Persuasive awareness creation, simplification of codes, trust between the regulators and the regulated and reduction of significant factors affecting code compliance steps in the right direction in fostering a promising voluntary compliance culture.

10. Promoting performance-based building code compliance in New Zealand

This chapter was developed from Publication № 9, which has been published in *the Journal of Performance of Constructed Facilities. DOI: 10.1061/(ASCE)CF.1943-5509.0001603.* This chapter aims to answer the research question RQ4 and research objective RO9.

Abstract

Building codes are mandatory documents that should be followed in all building constructions and other related works. However, complying with the building code requirements need to encourage the building code users and easing the compliance process as the building code provisions, standards and compliance document changes over time and could presents challenges in applying the building code requirements. Although the building code amendments help to improve the built environment resilience and enhance innovative techniques. This study aims to identify and explore factors that could promote and encourage building code compliance requirements considering regular changes in the building code, standards and compliance documents. A close-ended questionnaire survey was used for data collection for this study to measure the participant's opinion on improving and encouraging building code compliance in New Zealand. The questionnaire participants include structural engineers, project managers,

geotechnical engineers, local authorities, academic/researchers, licenced building officials, building contractors, architects, and building and consulting engineers. A five-point Likert scale was used in the questionnaire, and the obtained data were analysed with the Friedman test in SPSS software. The findings reveal that reduced bureaucracy, incentives, technical assistance and regular monitoring and inspection without notice encourages compliance in New Zealand. Also, the study identified transparency as a primary driver of building code compliance in New Zealand. Analysis from the Friedman test implies that there is no significant difference among all the criteria used in assessing the factors that encourage and drives building code compliance. Findings in this study suggest that proactive collaboration among the relevant stakeholders could be essential to encouraging building code compliance culture and for policymakers to improve on inclusiveness during the building code amendment process.

10.1. Introduction

Building code compliance is an essential issue that still gains much attention, especially as building code amendment offers an opportunity that encourages flexibility and innovative ideas. Compliance with the performance-based building code requirements could be challenging, considering the regular building code revisions and the application of the innovative techniques in practice (Duncan, 2005; B. J. Meacham, 2010a). The flexibility and innovative techniques introduced in performance-based building code promote the purpose of building code while allowing the code users to explore options beyond the prescriptive building code (Becker, 2008; Nwadike & Wilkinson, 2020d). Flexibility and innovative techniques in performance-based building code could have unintentionally increased the challenges within the application of the building code and its compliance, and it also provides many opportunities to achieve building code (Coglianese et al., 2003; B. J. Meacham, 2010a; Nwadike & Wilkinson, 2020d).

Encouraging code users to comply with the new building code provisions after amendment requires collaboration among all the relevant stakeholders, reduced compliance cost, strict punishment for serial offenders, proactive enforcement team, proactive training and sufficient public awareness on building code new provisions (APN, 2017b; Balch, 1980; Burby & May, 2000; Burby, May, et al., 1998; Jones & Vasvani, 2017b; Nwadike & Wilkinson, 2020c; Scholz, 1994; Spence, 2004). However, the efficacy of building code amendments immensely depends on how compliance with code provisions are encouraged (Ainuddin et al., 2014; Bilham & Gaur, 2013; Burby & May, 2000), identified that non-compliance causes high losses in disaster events such as an earthquake. Therefore, it is evident that non-compliance with building code amendment brings destruction to the built environment (Nwadike & Wilkinson, 2020c).

With the introduction of performance-based building code, compliance becomes a difficult puzzle to solve (Burby, May, et al., 1998; Nwadike & Wilkinson, 2020c), while there exist discrepancies on how compliance with the building code can be achieved (Nwadike & Wilkinson, 2020c). The regulatory authorities are confronted with options of either building technical staff capacity that can guide, detect and correct any compliance infringement or engage the code users to comply with the building code requirements (Burby, May, et al., 1998; Oladinrin & Ho, 2015). Many code users may have lost interest in complying with building code because of increasing code complexities, as (Abimbola & Keith, 2010; Baiche et al., 2006; Burby, May, et al., 1998; Duncan, 2005; Nwadike et al., 2019a) code users are not adequately trained with sufficient technical assistance. In New Zealand, complying with building code provisions are challenging as the code provisions change over time. Hence, it becomes imperative to encourage building code compliance.

This study identifies factors that promote, encourage and drive compliance with building code among the relevant stakeholders in New Zealand. Within the New Zealand setting, a closed-ended questionnaire was distributed to the relevant stakeholders that are involved in the use of building code. Based on the findings, the study offers potential insights on how building code users can be encouraged to comply with the building code requirements.

10.1.1. Research objectives

i) To identify the critical factors that encourage building code compliance.

ii) To make recommendations on how to improve and encourage building code compliance.

10.2. Balancing building code amendment with compliance

Building code, standards and compliance documents amendment has been applauded as a development that will improve the building code regulatory system, strengthen built environment resilience and encouraged compliance culture (B. J. Meacham, 2010a; Nwadike et al., 2019d). Catching up with these amendments could become more stressful as the code is regularly amended either with or without an interval (Nwadike & Wilkinson, 2020c). Besides, the innovative techniques in performance-based building code are increasingly applied without adequate training in many cases, to both the code users and the building officials that will approval the designs and construction documents (Burby, May, et al., 1998; Duncan, 2005; B. J. Meacham, 2010a; Nwadike et al., 2019d). This increase in the application of innovative techniques is significant as innovation suggestively outpacing the readiness of the New Zealand building and construction industry (Duncan, 2005; Hunn et al., 2002; May, 2003; B. J. Meacham, 2010a; Meeks & Brannigan, 1996). In New Zealand, the ministry of business, innovation and employment (MBIE) is keen on maximising innovation potentials to enable efficiency and productivity across the regulatory system (MBIE, 2018c).

Accordingly, complexity in building code (Arlani & Rakhra, 1988; Craig DeFriez, 2014; Listokin & Hattis, 2005; McLean, 2017), and quality of construction materials (Jones & Vasvani, 2017b), has been acknowledged. These issues have resultant effects on safety and compliance in building code practice. Delivering the primary purpose of building code in protecting society from unsafe practice and products requires minimising the innovative concepts that have the tendency to interrupt safety (Duncan John, 2000). Within the above context, there is a need to balance building code amendments, quality and innovative practice. Balancing scale within the context of this study can be defined as a scale that tends to provide an equilibrium point between regular building code amendments, quality and innovative techniques on the scale of compliance to deliver safety in the built environment. The balancing scale informs the building code regulators to amend the code provisions in such a manner that the application of innovative techniques and material quality can be scaled within the limit of safety and acceptable compliance level. Also, the balancing scale could offer a guide to the code users to limit all application of innovation within the compliance zone while maintaining building quality, performance and safety in the built environment. Although, performance-based building code has the fundamental difficulty in addressing how tight control and accountability can be balanced with an acceptable level of flexibility and innovation (May, 2003). The rationality behind the concept of balancing scale is to present a potential pathway to improve the built environment resilience through building code amendments while allowing both the code users and the building officials to be innovative (B. J. Meacham, 2010a; Nwadike & Wilkinson, 2020d). However, this balancing scale primarily depends on the willingness of the building code authorities in providing adequate resources for proactive training of the staff and the code users (B. J. Meacham, 2010a; Nwadike & Wilkinson, 2020c). Furthermore, it also requires a compliance approach that is focused on user-centred.

10.3. Encouraging inclusiveness within building code compliance

Encouraging compliance with building code requires the inclusiveness of all relevant stakeholders despite their interest differences and allowing their opinions to count respectively. Promoting inclusiveness in building code compliance requires creating a platform where all the relevant stakeholders can dialogue and resolve issues relating to the best practice of achieving compliance with the building code requirements. Figure 10.1 depicts how inclusiveness among the building code users could be encouraged, trained to handle changes within the building code provisions and enhance building resilience in the built environment. Figure 10.1 was developed based on the intensive review of existing literature carried out within the building code regulatory system.

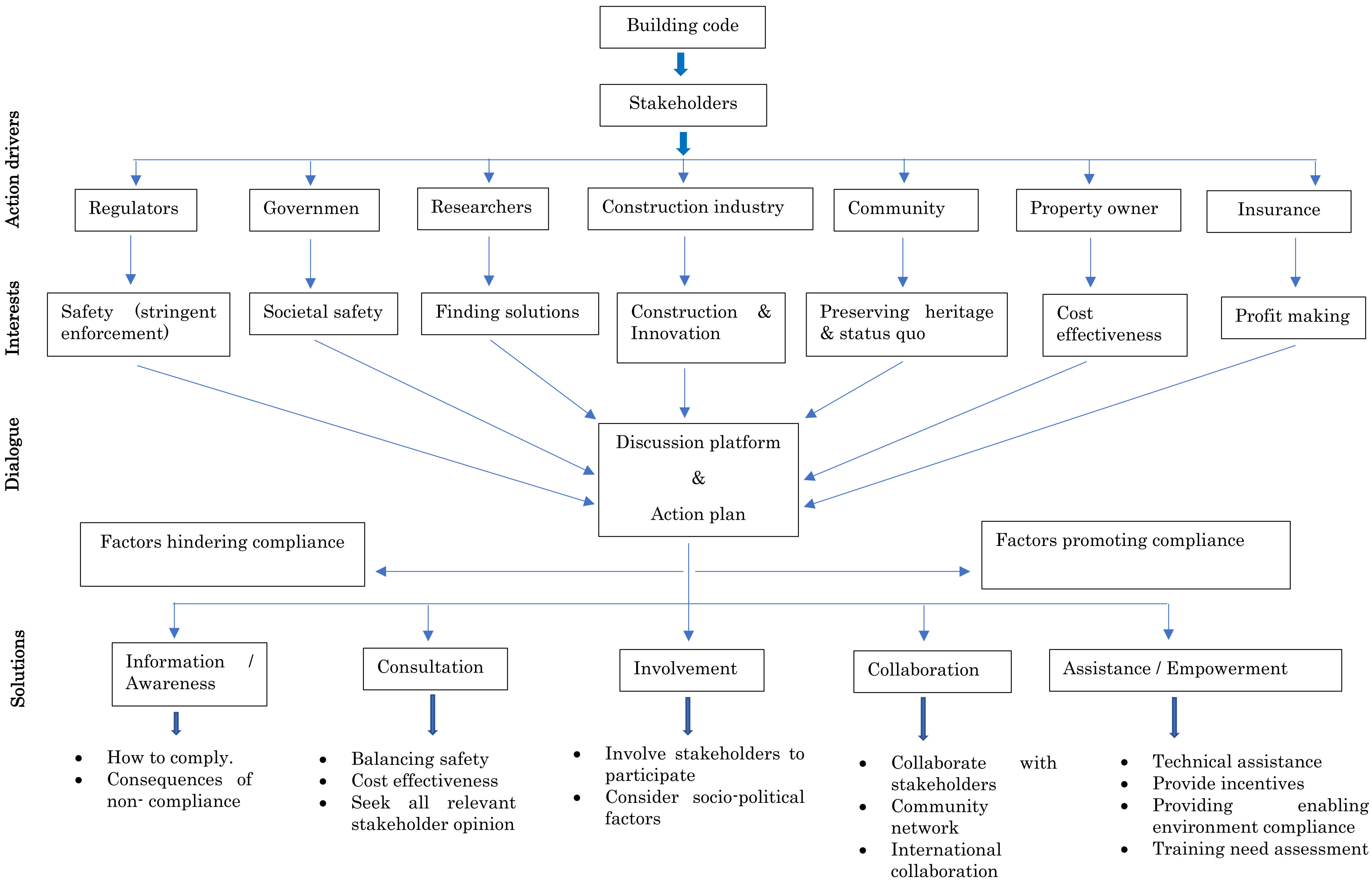


Figure 10.1: Encouraging inclusiveness in building code compliance.

The dialogue platform offers an avenue to discuss the best method to improve, include and empower all stakeholders towards complying with the building code requirements by eliminating factors that could hinder compliance and promoting the factors that enhance compliance. The efficacy of the action plan immensely depends on the implementation of the identified factors to boost compliance. The discussion platform offers an opportunity for a thorough assessment of issues surrounding building code compliance (Murphy, 2017). Also, the building policymakers and the building officials can use this medium to identify weakness in code compliance practice and provisions that are inadequate (Volha Roshchanka & Meredydd Evans, 2016).

There are different ways the code regulators can reach out to the stakeholders for meaningful engagement and discussions, such as public meetings, conference, working groups, technical committees, surveys, newsletters and webpages (Volha Roshchanka & Meredydd Evans, 2016). The solution criteria consist of adequate information, consultation, involvement, collaboration and technical assistance to all building code users at all levels. A collaborative approach in building code compliance involves flexibility, incentives and provision of technical assistance while findings ways of reducing compliance cost (Burby & May, 2000). Given the extensive nature of non-compliance with building code provisions and the necessity to inspire compliance, Ahmed et al. (2018) believed that stakeholders consultation is the vehicle to create a compliance culture among the code users. Hence, the stakeholder's inclusiveness can improve building code compliance.

10.4. Compliance concept

In New Zealand, the councils check and ensure that all code users comply with the building code requirements and administer adequate punishment for the offenders (MBIE, 2018c; Nwadike & Wilkinson, 2020c). However, building code is a unique technical document enacted into law with the aim of getting code users to comply with the code requirements voluntarily by providing technical assistance and easing the compliance pathways (Nwadike & Wilkinson, 2020c). Compliance with building code provisions becomes challenging, especially with regular building code amendments and the introduction of innovative techniques (Nwadike & Wilkinson, 2020d). The pursuit of achieving the purpose of building code amendment in ensuring sustainability and resilience in the built environment has made promoting compliance with the amended building code provisions a necessity. There is much emphasis on building code amendment without such similar considerations on how to implement and comply with the new changes (Nwadike & Wilkinson, 2020c). Amending building code and other related documents are essential, but complying with building code provision reduces the impact of a disaster in the built environment (Nwadike et al., 2019d). Improving compliance with building code could require creating an enabling environment through the implementation of the compliance concept 6P's that includes; people, process, planning, policy, product and performance, as illustrated in Figure 10.2.

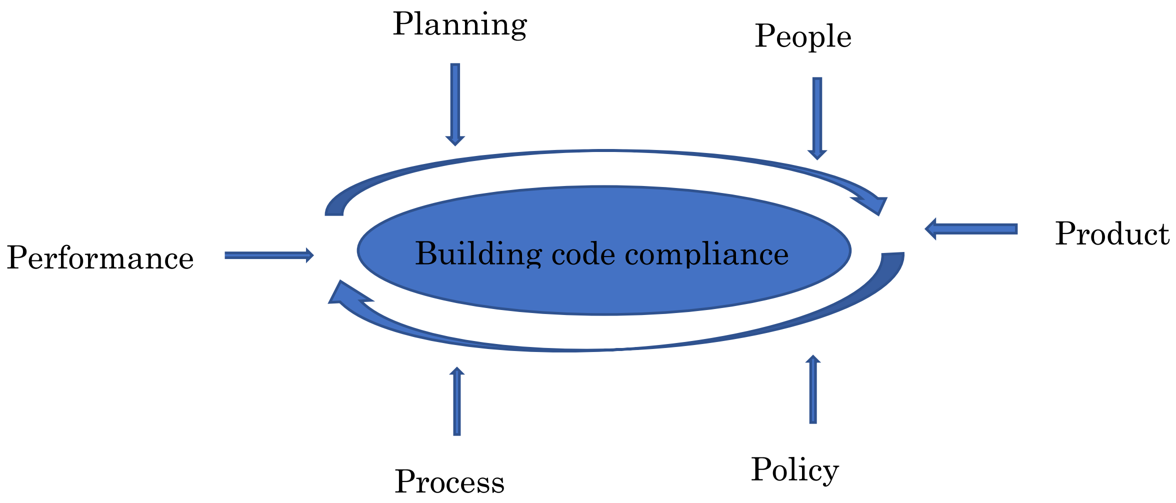


Figure 10.2: 6P's compliance concept.

The compliance concept is derived from reviews of existing literature archives around performance-based building code. Training of code users is inevitably one of the most practical steps in increasing the level of compliance with the code requirements (Burby & May, 1999; Duncan, 2005; B. J. Meacham, 2010a; Mumford, 2010; Nwadike & Wilkinson, 2020b). Equipping the people that use the building code is crucial as it helps them to know how to achieve the code provisions at all times(APN, 2017b; Duncan, 2005; Jones & Vasvani, 2017b; B. J. Meacham, 2010a; Nwadike et al., 2019d; Offei-Nketiah, Kwofie, & Duah, 2019) while informing the code regulators on the practicability of amendments in the building code through a feedback mechanism. Fostering compliance with building code requires that the people using the code must understand the code requirements, the objectives (Burby, May, et al., 1998), and the consequences of non-compliance to them and the entire built environment. After educating the people, there should be a systematic planning mechanism on how compliance goals can be achieved.

The planning stages involves both the government, the regulated and the regulators, with a primary focus on implementation, enforcement, compliance and building code amendment process. Most damages from the 1994 Northridge earthquake was attributed to poor compliance planning from the local government (Burby & May, 2000; Burby, French, et al., 1998). MBIE (2006) noted that planning is one of the factors that enhance building performance control functions in New Zealand. Planning assists all relevant stakeholders to understand their responsibilities in ensuring compliance is maximumly achieved without spending many resources on enforcement. Improving building code compliance requires that all building materials and products must comply with the requirements as stipulated in the building code and other related standards. Building products should be able to demonstrate compliance through testing, appraisal and code mark certification (MBIE, 2016k). Adequate information about the building products and materials should be included on the product to enhance usage and compliance, such as technical information, installation process, the scope of use and product maintenance (DBH, 2010). The efficacy of building code compliance requires a comprehensive policy scheme that will guide and oversees the applicability of building code. A well-developed policy could create an enabling environment that will motivate the code users to comply with the building code provisions. Accordingly, Abimbola and Keith (2010) opined that appropriate policies guided with developed building regulations encourage the code users to be more efficient in complying with building code. The policies need to be purposeful driven, consistent and effectively implemented before they can enhance building code compliance (MBIE, 2017e). While building regulatory policies support code compliance, the process of building code amendment is essential in achieving code compliance. A proactive approach to building code amendment that encourages compliance involves the participation of all relevant stakeholders. The process also includes how the planning, training of code users, building products and policy are implemented within the building code guidelines (Duncan, 2005; Nwadike & Wilkinson, 2020b). Compliance with building code entails having an outlined, simplified systematic process on how to achieve compliance. The performance of building code compliance needs to be regularly checked to evaluate and formulate new strategies of improving compliance (Nwadike & Wilkinson, 2020b). The approach would helps the building code regulators to measure the rate of compliance with the amended building code provisions against the established benchmark while outlining the necessity of avoiding liabilities through complying with building code requirements among the code users. The compliance concept takes a comprehensive approach that includes all areas that have the capacity to increase compliance with building code. Compliance concept if implemented, would serve as a guideline to achieve maximum compliance with building code requirements. This concept is significant in building regulatory system as innovative techniques are widely adopted in building code practice.

10.5. Research method

There are philosophies are underpinning every research, such as ontology and epistemology. Ontology forms the first research basis that provides a philosophical understanding of the nature of reality while shaping the methodological decision-making process (Jackson, 2013). This helps to recognise the certainty of the nature and existence of a subject matter under research consideration (Moon & Blackman, 2017). Accordingly, epistemological philosophy is the study of knowledge and extensively deals with how and where the knowledge is obtained while shaping and influencing data interpretation (Nicole, 2017). The philosophical perspectives of both ontology and epistemology give the theoretical thinking principles that are relevant to obtain knowledge of the reality of the subject under consideration (Moon & Blackman, 2017). The methodology is the whole approach undertaken to design research and answer the research questions and objectives, while a method is a technique used in data collection and analysis (Jackson, 2013).

Studying to identify and explore factors that promote building code compliance justifies the ontology and epistemology position that there exists a social reality in this study towards encouraging building code users to comply with the building code requirements. Hence, the study checked whether this social reality could be noticed and understood based on the building code stakeholders perspective within the New Zealand construction industry. The epistemology in this study employed a closed-ended questionnaire to justify and provide evidence that is logical and reasonable on the significance of promoting building code compliance. Considering the nature of the research objectives in this study, epistemological positivism was used, as it allows the use of the quantitative research method (Easterby-Smith et al., 2018).

In order to understand how building code compliance can be encouraged within the sector, a closed-ended questionnaire approach was applied to explore the opinions and perspectives of the relevant stakeholders in the building regulatory system. The rationale for the use of a closed-ended questionnaire is justified as it is cost-effective, gives a quick standardised response and provides an avenue to gather extensive data within an estimated short timeframe (Stefan Debois, 2019). The questionnaire survey was constructed from an intensive literature review carried out. The study population used in this research includes only those that use or regulate the building code within the context of New Zealand. The study used a purposeful sampling technique to choose the relevant stakeholders with vest knowledge on how compliance with building code can be encouraged within the sector to participate in the survey. The approach allows for a deliberate selection of the participants that can offer insightful details based on the research aims and objectives (Babbie, 2013; J. A. Maxwell, 2013; Neuman, 2014). The questionnaire survey participants were selected based on their relevant knowledge on New Zealand building code amendments. A pilot study was conducted with some relevant stakeholders within the building code regulatory field and all the corrections were effectively implemented before the questionnaire survey was distributed to the potential respondents. Based on the pilot study outcome, completing the questionnaire survey takes approximately 45 minutes. The relevant stakeholders include those that actively use the building code and people involve in regulating the building code regulations and services, both private, independent entities and government agencies. A total of 250 questionnaires were distributed, 121 questionnaires were returned, and only 116 questionnaires were fully completed and hence used for this study. The response data from the returned and completed questionnaire were collated, coded with numbers and analysed using the Friedman test in IBM Statistics Package for the

Social Sciences (SPSS) software. The data entered in the IBM SPSS software were double-checked for accuracy to eliminate any possibility of error. This study used a five-point Likert scale where 1 is regarded as strongly disagreed and 5 as strongly agreed (Likert Rensis, 1932). The five-point Likert scale was used in this study to increase the response rate, improve the quality of information, reduced the frustration level of the survey respondents and easy platform for data analysis (Babakus & Mangold, 1992; Dawes, 2008). Figure 10.3 shows the schematic explanation of the questionnaire process used in this study.

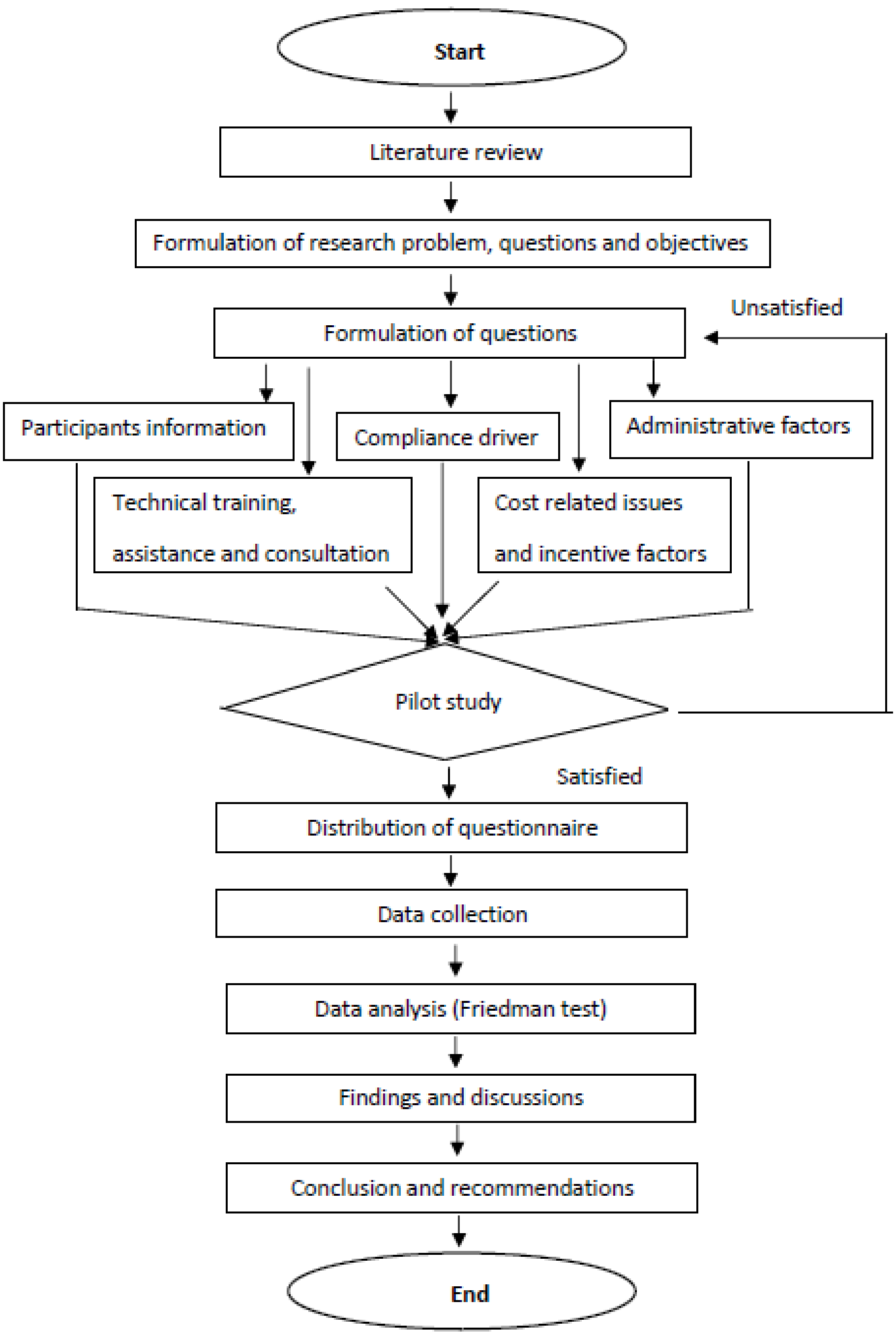


Figure 10.3: A schematic explanation of the questionnaire process.

For this study, the survey participants include structural engineers (50%), project managers (12.90%), geotechnical engineers (9.50%), local authorities (7.8%), academic/researchers (6.90%), licenced building officials (6%), building contractors (3.40%), architects (1.70%), building and consulting engineers (1.70%).

Furthermore, the study used Cronbach's alpha coefficient α technique (Gliem & Gliem, 2003; Tavakol & Dennick, 2011) to measure the degree of internal consistency and reliability of all completed items in the questionnaire, as follows:

$$\alpha = \frac{K.\overline{C}}{\overline{V} + (K-1).\overline{C}} \geq 0.7 \qquad (1)$$

Where K is the number of questions in the questionnaire, $\overline{C}$ is the average covariance among the items in the questionnaire, $\overline{V}$ is the average variance of the items in the questionnaire.

The Cronbach alpha coefficient α of 0.755 > 0.7 from the SPSS analysis indicates a good measure of internal consistency (Gliem & Gliem, 2003) among the factors that encourage and drive building code compliance in the questionnaire items, as shown in Table 10.1.

Table 10.1: Friedman test case processing summary for building code compliance.

Case processing summary			
		No. of participants	%
Case	Valid	116	100.0
	Excluded	0	0.0
	Total	116	100.0

Reliability statistics			
	Cronbach's Alpha	Cronbach's Alpha Based on Standardized items	No. of questions
	0.754	0.755	18

Summary Item Statistics	Mean	Minimum	Maximum	Range	Maximum/ Minimum	Variance
Item Means	4.036	3.724	4.405	0.681	1.183	0.057
Item Variance	0.920	0.468	1.237	0.768	2.640	0.036
Inter-Item Covariances	0.87	-0.192	0.529	0.721	-2.755	0.014
Inter-Item Correlations	0.95	-0.286	0.539	0.825	-1.887	0.018

Also, the study adopted the null hypothesis that no significant difference exists within each questionnaire items that measure the factors that encourage and drive building code compliance. Hence, if the significant value *(p)* is less than 0.05, the null hypothesis should be rejected as a decision rule.

10.6. Findings and discussion

This section discusses the result findings based on the data collected from the questionnaire survey. The resulting outcome emphasises factors that could encourage building code compliance among the building code users. Also, the study findings could facilitate the decision-making process within the building regulatory system and the construction industry. The findings from the questionnaire survey responses from the Friedman test in SPSS test analysis are discussed below.

10.6.1. Encouraging building code compliance through technical training, assistance and consultation

Based on the returned questionnaires regarding factors that encourage building code compliance in New Zealand, 66.4 per cent of the survey respondents strongly believed that providing free to low-cost technical assistance encourages compliance with building code provisions. The outcome in this study is in line with previous research regarding how free to low-cost technical assistance helps to increase understanding (Burby & May, 2000), foster voluntary compliance (Burby & May, 2000; Burby, May, et al., 1998), and make a clear interpretation on code provisions (Olshansky, 1998). Technical assistance is essential as performance-based building code comes with some challenges, mainly as innovation and flexibility have paved the way for the diverse interpretation of building code requirements (Lundin, 2006; B. J. Meacham, 2010a; Meacham Brian, 2008). Considering the percentage of the respondents that strongly believed on technical assistance, this study established the importance of providing enhanced and supportive technical assistance to the code users.

In examining the efficacy of regular consultation with relevant stakeholders in the building code industry, 65.5 per cent to an extent agreed that regular consultation motivates code users to comply with the code requirements. Although the Ministry of Business, Innovation and Employment (MBIE) consult with the code users (MBIE, 2020d); however, the findings in this study propose for a more meaningful, proactive and supportive consultation such that the building code policymakers can effectively implement the stakeholder's contributions. Regular consultation helps to understand the challenges facing code users and different opportunities to facilitate compliance (APN, 2017b; Nwadike & Wilkinson, 2020c). Furthermore, the aim and objectives of the proposed consultation should be clearly outlined to all the stakeholders to enhanced constructive feedback.

In the quest to increase the level of compliance among the building code users, the responses from the questionnaire (63.8 per cent) show that training of code users on changes in the building code requirements encourage a high level of compliance. Consistent training on new developments in building code increases the understanding of the code users, raises competence level, reduces some level of code complexities and enhance voluntary compliance (Ahmed et al., 2018; Burby, May, et al., 1998; Duncan, 2005; MBIE, 2018c; B. J. Meacham, 2010a). Training building code users increase productivity and faster delivery of construction works (Duncan, 2002b; Michael Mills, 2010b). Encouraging training of code users is necessary for New Zealand, as (Duncan, 2005) claimed that the 2002 leady building crisis in the country was a result of inadequate systematic training relating to building skills. However, before training, there is a necessity for training need assessment (Meres et al., 2012) on the code users knowledge in building code amendments and their associated documents. The findings from this study suggest that lack of regular training has the tendency of unintentionally contributing to non-compliance with the building code amendments. The study also supports a continuous process of training as new individuals join the sector.

Furthermore, training code users helps to reduce repeated errors in the application of the news changes made in the building code.

The respondents of the survey (62.9 per cent) in this study emphasised that having professional technical skilled staff encourages compliance with building code as they have the capacity to detect and correct code violations. MBIE (2017f) stressed the need for professional technical staff in performing building control functions. An adequate number of competent technical staff creates an environment for enforcement and compliance with the building code (Burby, May, et al., 1998; Jones & Vasvani, 2017b; Nwadike & Wilkinson, 2020c; Yates, 2002a). Besides, Meres et al. (2012) believe that qualified technical personnel in the building code sector improves code compliance. Findings in this study suggest that technically skilled officials help to direct the code users in the right perspective in terms of providing sufficient technical assistance to encourage and achieve compliance. In New Zealand, technically skilled building officials are needed, as the country building code allows for innovation and flexibility. Figure 10.4 shows the respondents responses based on the Friedman test.

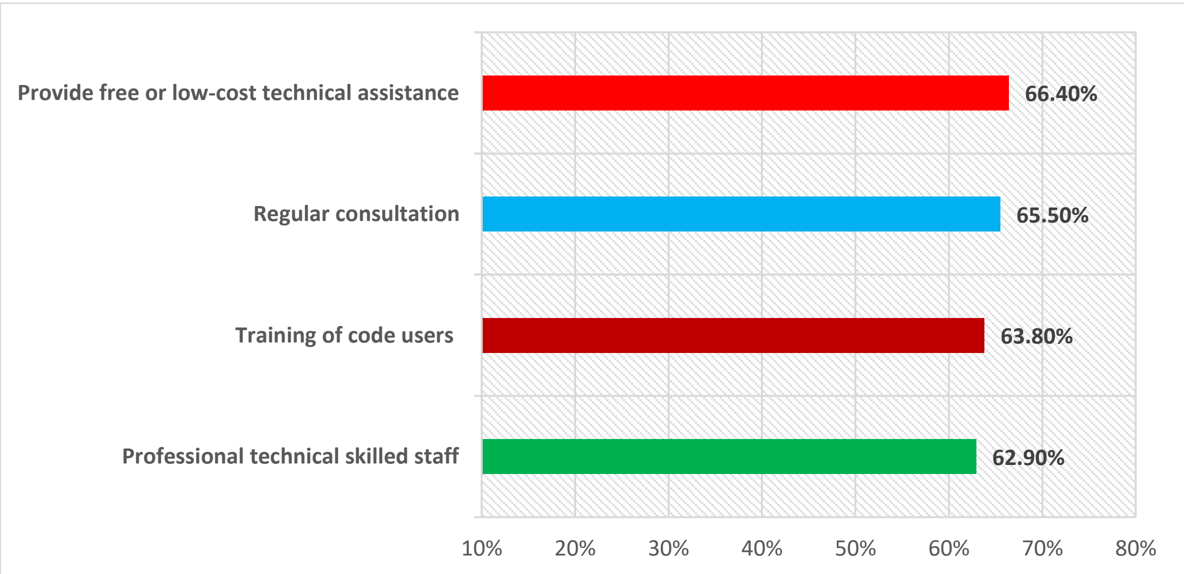


Figure 10.4: Encouraging building code compliance through technical training, assistance and consultation.

Findings from this study with a high proportion of aggregated mean (M = 4.23) and standard deviation value (SD = 0.89) suggests that training, consulting and provision of technical assistance can increase compliance. From the SPSS analysis in this study, the Friedman test ($p = 0.001 < 0.05$) implies that the null hypothesis should be retained. Tables 10.2 shows the Friedman test results and summary item statistics for technical training, assistance and consultation.

Table 10.2: Friedman test case processing summary for technical training assistance and consultation.

Friedman test results

	Mean rank
A1	2.22
A2	2.88
A3	2.09
A4	2.81

	Test statistics
N	116
Chi-Square	43.293
df	3
Asymptotic significance	.001

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum/ Minimum	Variance
Item Means	4.226	4.034	4.397	0.362	1.090	0.030
Item Variance	0.824	0.468	1.237	0.768	2.640	0.140
Inter-Item Covariances	0.037	-0.167	0.151	0.318	-0.908	0.014
Inter-Item Correlations	0.041	-0.202	0.217	0.419	-1.071	0.022

10.6.2. Encouraging building code compliance through cost-related and incentive factors

Figure 10.5 shows the respondents opinion on how cost-related factors can help to encourage compliance with the building code.

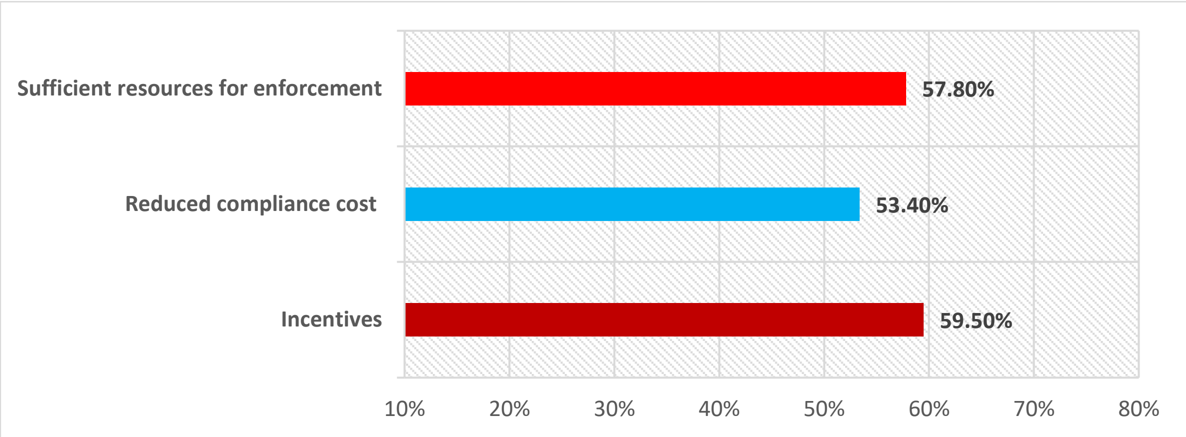


Figure 10.5: Encouraging building code compliance through cost-related and incentive factors.

Based on the returned questionnaires, 59.5 per cent of the respondents agreed that the provision of incentive to the building code users would encourage compliance. Previous research from Anwar, Aliani, and Amatyakul (2012) aligned with the findings in this study that providing incentives, keeping the building code language simple and raising awareness with suitable mechanism encourages compliance. Spence (2004) also noted that compliance incentives could be financially inclined, including either tax incentives, low-interest loan, reduced insurance premium and exemption from planning controls. Increasing the capacity of voluntary compliance with the building code requires the provision of sufficient incentives (Ahlbrandt, 1976; Burby, May, et al., 1998; Scholz, 1994), hence lowering compliance cost as a form of incentives facilitates compliance among the code users (Balch, 1980; Nwadike & Wilkinson, 2020c; Scholz, 1994).

The above findings indicate that providing incentives to code users can boost compliance.

In total, 53.4 per cent of the respondents placed priority on reducing the compliance cost as a measure to encourage compliance with building code. Reducing compliance cost should be every government priority as it increases efficiency and productivity in the building industry (Michael Mills, 2010b). Furthermore, lowering compliance cost and rewarding those that fully and willingly complied inspire compliance culture (Balch, 1980; Scholz, 1994). However, cost and benefit assessment are needed to balance the advantages of code amendment to achieve code compliance (MBIE, 2017c), and building quality (Michael Mills, 2010b). The unnecessary cost associated with compliance serves as a barrier in encouraging building code compliance (Bullen & Love, 2011; Levi-Faur, 2011; May, 2003). Also, compliance cost should be reduced such that the cost of compliance will be cheaper compared to the cost of non-compliance (May, 2004; Nwadike et al., 2019d). Hence, the findings in this study reveal the importance of compliance cost reduction as it increases the rate of compliance with building code. The study also advocates for more reduced compliance cost while reviewing other factors that contribute to non-compliance with the New Zealand building code.

The respondents in this study (57.8 per cent) strongly agreed that sufficient resource for enforcement would enhance compliance. Providing resources for code enforcement is critical as it helps to ensure that the purpose of building code amendment is achieved for societal benefits (Nwadike et al., 2019d; Yates, 2002a). The enforcement resource comes in different forms such as sufficient technical building official, financial resources, proactive regulatory authorities, conductive enforcement environment and supportive policies (Burby & May, 2000; Meres et al., 2012; Spence, 2004; Yates, 2002a). Insufficient resources for building code enforcement is among the primary reason for non-compliance (Meres et al., 2012; Yates, 2002a). Without sufficient resources, the findings in this study suggest that enforcement of building code may not be successful. Nevertheless, there is a need to have an effective enforcement mechanism.

The SPSS analysis in this study shows a high proportion of the aggregated mean value of 3.92 and a standard deviation value of 0.96. This suggests that cost-related and incentive factors encourage compliance with building code while supporting the code users to comply. Findings from the Friedman test ($p = 0.001 < 0.05$) indicates that the null hypothesis in this study should be taken, as shown in Table 10.3.

Table 10.3: Friedman test results for cost-related and incentive factors.

Friedman test results

	Mean rank
B1	2.40
B2	1.80
B3	1.81

	Test statistics
N	116
Chi-Square	36.384
df	2
Asymptotic significance	.001

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum/ Minimum	Variance
Item Means	3.922	3.724	4.302	0.578	1.155	0.108
Item Variance	0.921	0.828	0.995	0.168	1.202	0.007
Inter-Item Covariances	0.103	-0.095	0.476	0.571	-4.998	0.084
Inter-Item Correlations	0.120	-0.098	0.539	0.638	-5.481	0.105

10.6.3. Encouraging building code compliance through administrative factors

According to 65.5 per cent of the respondents, reducing the bureaucratic process in the administration of building regulation encourages compliance with building code. Encouraging building code compliance requires a reduced administrative bureaucracy, as (Gilles Maria, 2018) calls for a simplified process of building code regulatory practice. Charytonowicz and Falcão (2018) noted the importance of reducing bureaucratic measures in building control system as it helps to reduce cost and encourage compliance. The bureaucratic system causes unnecessary delays, affects enforcement and compliance and stiffens progress in building control (B. J. Meacham, 2010a; Offei-Nketiah et al., 2019). The respondents in this study pointed out that the bureaucratic system causes non-compliance with the building regulatory practice. Hence, there is a need to reduce bureaucracy in building regulation in New Zealand.

Moreover, 56.0 per cent of the survey respondents agreed that severe punishment for serial offenders would compel code users to comply with the code requirements. The study findings aligned with previous studies, as (Yates, 2002a) believes that severe offenders are not correctly punished as the violators are charged with negligence rather than a breach of government act or regulation. The efficacy of encouraging building code compliance occurs when code users are aware of the severe consequences of non-compliance. Therefore, the willingness to comply with building code provisions are driven on the basis that cost of non-compliance is much higher compared to adherence to code requirement (Burby, May, et al., 1998; Nwadike et al., 2019d). Burby, May, et al. (1998) called for inescapable uniform punishment for all building code violators, which can include stop-work order, fines and inspection delays. In general, the study finding confirms the importance of severe punishment as a measure of encouragement towards complying with building code requirements.

The respondents expressed their perception of factors that encourages compliance with building code. From the study, 49.1 per cent are of the opinion that having a country-specific building code inspires code compliance. Spence (2004) opined that most countries adopt building code without adequate technical capacities. Nwadike et al. (2019d) noted that it might be challenging to comply with the building code when the code is not streamlined to suit the needs of such a country. The findings reveal that a building code within the context of a country enhances compliance.

Only 47.4 per cent of the respondents believed that regular monitoring and inspection of construction without notice enhances compliance with building code. Compliance with building code is best encouraged when monitored effectively with sufficient technical personnel for inspection (Burby, May, et al., 1998). MBIE (2016h) notes that non-compliance usually decreases with an increase in monitoring. However, the efficacy of monitoring compliance primarily depends on the proactive nature of the engaged technical personnel in carrying out their duties (Yates, 2002a). In the case of changes to the building code requirements, a higher level of monitoring may be required. In New Zealand, the councils have the responsibility to monitor and schedule building inspections (MBIE, 2016f). Based on the participant's responses, monitoring and inspection are not considered as pressing challenge. However, the findings in this study suggests for a more proactive measure.

From the above findings, the aggregated mean value is 4.05, and the standard deviation is 0.98, which implies that encouraging building code compliance requires a substantial improvement in building code administrative measures in New Zealand. Figure 10.6 shows the respondents perspective regarding administrative factors surrounding building code practice in New Zealand, while Table 10.4 shows the Friedman test results for administrative factors.

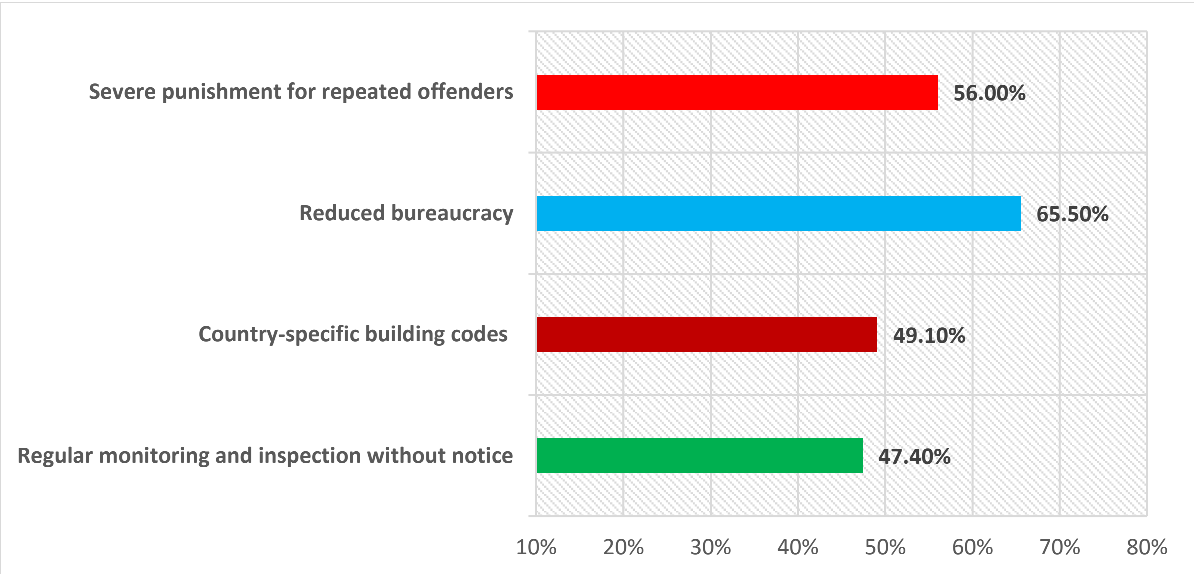


Figure 10.6: Encouraging building code compliance through administrative factors.

Table 10.4: Friedman test results for building code administrative factors.

Friedman test results	
	Mean rank
A1	2.31
A2	3.06
A3	2.23
A4	2.40
	Test statistics
N	116

Chi-Square	41.033
df	3
Asymptotic significance	.001

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum/ Minimum	Variance
Item Means	4.050	3.897	4.405	0.509	1.131	0.057
Item Variance	0.961	0.824	1.121	0.297	1.361	0.015
Inter-Item Covariances	0.61	-0.079	0.241	0.321	-3.039	0.015
Inter-Item Correlations	0.63	-0.90	0.235	0.325	-2.625	0.016

10.6.4. Compliance drivers with building code

The survey participants were asked to express their individual opinions on the factors that drive building code compliance among the code user, as shown in Figure 10.7.

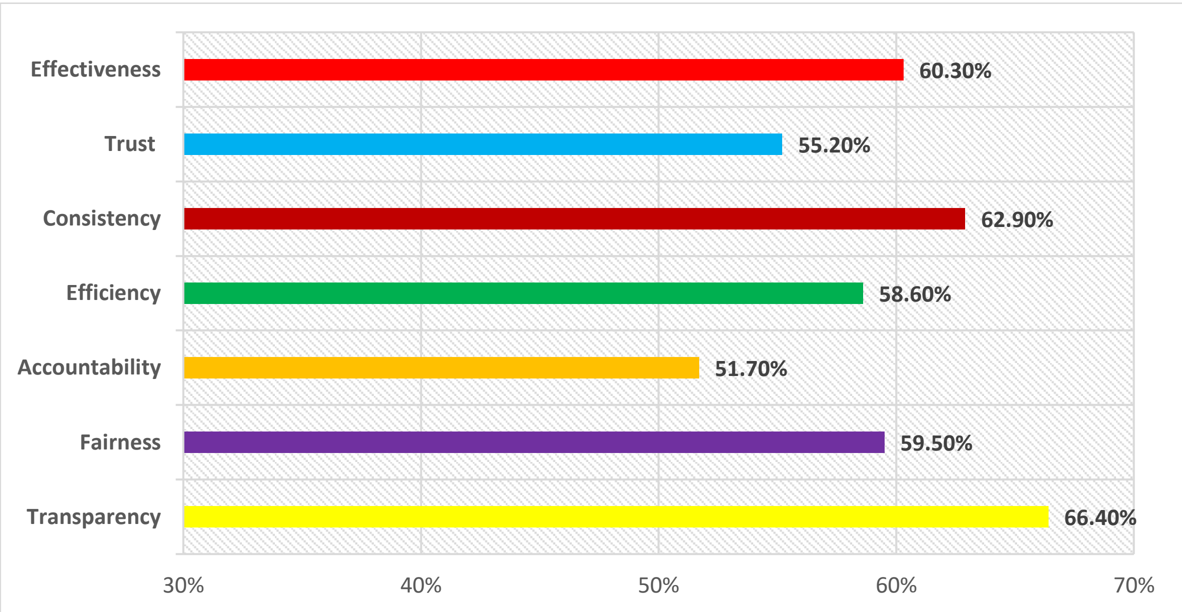


Figure 10.7: Drivers for compliance with building code.

Above all, the respondents rated transparency (66.4 per cent) and consistency (62.9 per cent) within the building regulatory system as the most driving factors of compliance with the building code provisions. Also, the respondents agreed that effectiveness (60.30 per cent), fairness (59.5 per cent), and efficiency (58.6 per cent) in building code contributes to driving and coordinating the activities of building code compliance. However, only 55.2 per cent and 51.7 per cent of the respondents believed that trust and accountability could drive the code users to comply with the provisions of the building code. Transparent process of building code amendment, implementation, enforcement with the features of voluntary compliance promotes the willingness of stakeholders to comply with the building regulations (APEC, 2015; APN, 2017b; Nwadike et al., 2019d). Compliance with building code requirement increases when the code users develop trust and perceive the regulatory process as effective, efficient, consistent and accountable (Margaret Levi, 1988; May, 2004; Moullier, 2014). Furthermore, introducing a fair measure to all code users where everyone is treated equally and apply punishment to serial violators to foster compliance (Burby & May, 2000; Yates, 2002a). The results from this study demonstrate that increasing the implementation of compliance drivers increases the level of compliance among the code users in New Zealand.

From the Friedman test analysis, the cumulative mean value of 3.97 and standard deviation of 0.97 indicates the need to improve building code compliance drivers among the building regulating agencies and building code users for successful implementation of building code requirements within the construction industry. Table 10.5 shows the Friedman test results for compliance drivers with building code.

Table 10.5:Friedman test results for compliance drivers with building code.

Friedman test results	
	Mean rank
D1	3.81
D2	3.88
D3	3.85
D4	3.61
D5	4.04
D6	3.59
D7	4.21
	Test statistics
N	116
Chi-Square	73.871
df	6
Asymptotic significance	.001

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum/ Minimum	Variance
Item Means	3.968	3.767	4.405	0.638	1.169	0.045
Item Variance	0.951	0.791	1.078	0.287	1.362	0.014
Inter-Item Covariances	0.128	-0.139	0.376	0.514	-2.709	0.020
Inter-Item Correlations	0.138	-0.147	0.386	0.533	-2.628	0.022

10.7. Conclusion

This study presented critical factors that encourage and drive building code compliance in the New Zealand context. The study demonstrates how all the relevant stakeholder's opinions can be accommodated to enhance compliance inclusiveness in building code practice. The study used a closed-ended questionnaire as the primary source of data collection, while the Friedman test was used to analyse the collected data. The study used the Cronbach alpha α coefficient technique to measure the degree of internal consistency and reliability of all completed items in the questionnaire.

The study demonstrated a high positive impact on the need to encourage building code users to enhance compliance with the building code, especially when the code is amended, which justifies the need for this study. It is evident from the findings in this study that a high proportion of the survey respondents believe that providing free or low-cost technical assistance to code users has a high tendency to motivate and encourage building code compliance. Offering technical assistance, training and regular consultation to code users create a sense of belonging that allows the code users to achieve compliance voluntarily. The study reported that the majority of the survey participants believed that all factors relating to reduced cost, sufficient resources and incentive are essential towards creating an enabling environment that supports compliance with building code. Considerably, most of the users are likely to comply when there are benefits attached to compliance in New Zealand. Also, the questionnaire respondents strongly believed that reducing the bureautic process associated with the administration of building regulations can increase the level of compliance. The study findings also established the need to punish serial violators of building code compliance to encourage other code users. A low proportion (47.4 per cent) of the participants that considered regular monitoring and inspection without notice could suggest that it is not among the pressing factors that encourage compliance within the New Zealand context. The findings in this study strongly support the significants of building code compliance drivers such as transparency, effectiveness, consistency and fairness within the building regulatory system.

Building code compliance progresses in an atmosphere where the regulated have confidence in the activities of the regulators. Balancing building code amendment, building quality and innovative techniques increases compliance, safety measures and resilience in the built environment. However, the balancing scale requires the collaboration and inclusiveness of all the relevant stakeholders to encourage compliance. Furthermore, building code compliance can be improved through the effective implementation of the compliance concepts. Building code compliance could be made more attractive to code users by reducing the complexities associated with building code requirements. Accordingly, the study suggests the recruitment of qualified staff and training of staff that have the skills to detect and correct compliance violations with adequate punishment for the offenders. Considerably, this study calls for urgent development of policies and strategic measures that will promote efficient building code enforcement. The goals of building code compliance could be accomplished by raising awareness and educating the code users on the importance and consequences of non-compliance.

Within the course of this study, there were some questions regarding the financial capacity of the regulatory authorities in offering free technical assistance to the code users and employing competent staff that can detect, correct and enforce compliance. Also, the capability of the building regulatory authorities and policymakers to balance the differences within the stakeholder's interest was raised. These emerged challenges would be addressed in future studies. The approach to encourage code users at all levels should be considered as it can inspire voluntary compliance and increase the resilience of the built environment. Encouraging building code compliance is a logical approach to sustain the primary goals of building regulatory system in New Zealand. Furthermore, the study acknowledged that the higher representation of the structural engineers in the questionnaire survey respondent mix might have influenced the results in this study. Future studies should consider reducing bias by sampling equal respondents across all building code users.

11. Identification of parameters to develop a theoretical framework to improve building code amendment in New Zealand

This chapter was developed from Publication № 10, which has been published in the 54th International Conference of the Architectural Science Association (ANZAScA) 2020. This chapter aims to answer the research question RQ5 and research objective RO10.

Abstract

This chapter presents an evidence-based framework by identifying parameters that promote New Zealand building code improvement. In justifying the rationale behind the need to develop a framework, the study conducted a narrative review of the current knowledge within the building code context to enhance its functions. The study identified five action priority features such as regulation and administration, design and implementation, enforcement, compliance and amendment process. Each action priority features has established criteria that describes what needs to be improved. The identified parameters offer a unique opportunity in balancing stakeholders diversity interest while ensuring a transparent improvement process. The implementation of the proposed framework would facilitate a robust building code improvement.

11.1. Introduction

Many countries around the globe have either developed or adopted their building code, with many transiting from prescriptive-based to performance-based regulatory system. The performance-based code facilitated innovative techniques, flexibility and reduced regulatory cost (Mumford, 2010). However, the building has progressed gradually over time to meet the societal needs regarding safety, the resilient built environment and public health (Kumar, 2017; MBIE, 2020c; Offei-Nketiah et al., 2019). Accordingly, building code has played a significant role in reducing disaster impacts (Jones & Vasvani, 2017b).

Despite the benefits of building code practice, some limitations exist that demonstrates the need for improvement. Considerably, lack of training with the introduction of amended requirements, inadequate awareness, poor legislative environment, code complexities, non-compliance and lack of qualified staff have been recognised as factors that could limit building code benefits (Burby & May, 2000; Duncan, 2005; Gülkan, 2001; Nwadike et al., 2019c; Spence, 2004). In some cases, poorly skilled code users with poorly written building code lead to wrong interpretations and application of building code requirements in design and construction, which could be a result of regulatory oversight on the part of the regulators (Michael Mills, 2010b). According to Jain (2002), the non-mandatory use of the building code in design and construction contributed to the code limitations. Similarly, the quest to reduce disaster risks, enhance the potentials of building code and simplify its application have also made code improvement a necessity. The building code improvement requires the input and participation of relevant stakeholders irrespective of their diverse interest, supervised by the building code regulators at all levels. Furthermore, the building code amendment process creates an avenue to improve the building code and other related documents (Nwadike & Wilkinson, 2020a).

This paper explores relevant factors that could improve building code amendment in New Zealand. A narrative literature review of existing documents (Green et al., 2006; Juntunen & Lehenkari, 2019; Rumrill Jr & Fitzgerald, 2001) was conducted to identify the knowledge gaps which enables the establishment of relevant factors to develop a proposed framework that improves the application and use of building code in New Zealand. The findings from this paper offer an insightful basis for improving the New Zealand building code and the amendment process.

11.2. Why building code improvement

The concept of improving building code implies changing existing building regulations, requirements, and methods of application that are no long tenable to ensure that the primary purpose of developing building code is achieved. Improving building code involves the participation and contribution of all stakeholders. The increasing deficiencies in building code practice as a result of environmental changes and noticeable dissatisfaction of building code outputs in building performance suggests the need to improve the building code regulations (Nwadike et al., 2019a, 2019c; Spence, 2004; Wayne Thompson, 2005). The building code, in some situations, failed to address quality in design and construction (Wayne Thompson, 2005), which has resulted in societal fear as the built environment changes over time. Building quality ensures a safe, durable, and healthy built environment. It offers an excellent opportunity to improve building features that align with the Ministry of Business, Innovation, and Employment (MBIE) aim of improving building code to keep pace with the modern design and construction methods (MBIE, 2020a). This will reflect in the building performance before, during, and after any extreme loading conditions in the built environment. Improving building code creates the pathway to consistently address the bare minimum standards stipulated in the building code requirement (Carla Williams, 2016), as the human environment changes with time.

The introduction of a performance-based building code requires periodic improvement of building regulations and requirements since it presents innovative techniques and flexibility in building design and construction systems. The improvement becomes necessary as innovation and flexibility are consistently outpacing the readiness of all stakeholders involved in the building regulatory system (Duncan, 2005; B. J. Meacham, 2010a). The innovative techniques have given rise to different interpretations of building code requirements by code users and building officials (Lundin, 2006; B. J. Meacham, 2010a; Meacham Brian, 2008). The diverse code interpretation has led to the question of the clarity of building code requirements and the choice of terminologies used in describing building code. Consequently, the leaky building situation in New Zealand demonstrates how innovative techniques can outpace readiness (Duncan, 2005; Hunn et al., 2002; May Peter, 2003). Additionally, a similar incident was reported in Vancouver, Canada, and some parts of the South East in the United States of America (Meeks & Brannigan, 1996). However, other factors may contribute to the rate at which innovation overtakes the building industry readiness, such as cost-cutting practice, poor work quality, failure in the construction process, knowledge deficiency and lack of coordination among the stakeholders (Duncan, 2005; Hunn et al., 2002; May Peter, 2003; Nigel Isaacs, 2018). Improving building code is viewed as a better way to incorporate new findings, materials, construction methods, and innovative techniques to minimise the impacts of disaster in the built environment.

11.3. Situations confronting building code improvement

Many situations are encountered when considering measures for improving the building code. Building code regulators, policymakers, and other stakeholders are faced with the question of what to improve, how to improve it, and when to improve the identified areas in the building code. Before amending any section of the building code, standard, or compliance documents, it is crucial to consider the socio-economic implications of the intended changes and how the new changes can be adequately presented to the code users. Before making changes in the building code and other associated documents, the building regulators and the policymakers seek ways to meet the expected changes in the building code with regards to implementation and compliance (Ametepey, Ansah, & Edu-Buandoh, 2015; Auckland Council, 2020). The critical success of any proposed changes largely depends on how the expected positive outcomes can be accepted in the industry, building consent authorities, and building practitioners (Michael Mills, 2010b). Also, the manner of presenting building code changes to the end-users for implementation should be considered, as it is expected to come with resourceful training for all, supports and how compliance with the new changes could be achieved (Duncan, 2005).

The MBIE is responsible for monitoring, detecting any deficiency in the regulation or poor building performance, and the need to improve the building code as the institution is saddled with the responsibility to review and maintain the building code (MBIE, 2019a). However, other regulatory agencies such as the Building Consent Authorities and Territorial Authorities are obligated under the Building Act to support the MBIE to achieve and maintain the building regulatory system in New Zealand (MBIE, 2019a). According to section 172 of the Building Act established a Building Advisory Panel (BAP) with special duties such as ensuring a constructive dialogue between the construction sector and the MBIE (MBIE, 2019a). The regulatory agencies and the BAP helps to create an enabling environment that ensures the building code continues to deliver the best building performance with innovative approaches that can be globally acceptable.

The consultation process that proceeds before the building code amendment helps to make the process transparent, consistent and relevant stakeholders to make contributions that enhances the decision-making process as largely overseed by the MBIE. The relevant stakeholders include the building code regulators, construction industry professionals, building owners, the government, insurance institutions and the research institutions. The stakeholders come to the table of contribution with diverse interests that potentially serve their respective benefits. The building code regulators are mostly concerned with safety precautionary measures, which they achieve by applying strict building requirements, regular building code amendment and the stringent enforcement process through the

Territorial Authorities and Building Consent Authorities. Also, the regulators maintain and ensure strict compliance with the building requirements (Aigwi, Ingham, Phipps, & Filippova, 2020). The construction industry professionals believe in the application of innovative techniques in construction that serves the taste of the time. The construction industry professionals seek clarity of the building code requirement as they may bear the most liability of the construction process. The building owners find ways to achieve cost-effectiveness and the return on investments. The government roles are centred on creating policy legislation that ensures societal safety and improved building code. Within the context, the insurance institutions are concerned about the profit on investment. While the research institutions focused on finding solutions that seek to improve the building code and its applications; however, such findings may not consider the cost implications associated with the recommended solutions. Within the above context, it is imperative to identify parameters, develop a theoretical framework and conduct subject expert matter interview, and carefully analyse the outcomes to come up with measures that can improve the building code while balancing the diversity in the stakeholder's interest.

11.4. Framework description based on action priority features and criteria

The framework described in this section presents five critical features, such as regulation and administration, enforcement, compliance, and amendment process.

The framework criteria are used to measure and assess the action priorities. The action priorities features are discussed in details below:

11.4.1. Building regulation and administration

Building regulation is a significant aspect of the building control framework, made in accordance with the New Zealand Building Act. The building regulation provides building control details such as change of use, specified system, earthquake moderation and related levy rates (MBIE, 2018a) while ensuring compliance, enforcement with the building code(Ashburton District Council, 2019). In New Zealand, the building regulation has undergone several changes since enacted into law to improve the building performance and create an enabling environment that drives innovative techniques. Accordingly, the building regulation provides user-friendly requirements, efficient services and timely delivery through legislative policy measures (Ashburton District Council, 2019).

Any building design and construction method that does not follow all the stipulated building regulation requirements are not deemed fit to be constructed, as such design and construction pose a high risk in the built environment. Given the nature of building regulations, some stakeholders consider building regulations and administrations as obstructive to innovative technologies, unnecessary building cost, restricts new building materials and social discrimination of low-income earners as they may not be able to afford building cost (Arlani & Rakhra, 1988). Seeking the opinion of the relevant stakeholders to improve the building regulations and the administration of the code requirements becomes necessary.

The framework development based on the regulation and administration is measured under six criteria as a source to improve the building and its application. The criteria are well discussed below:

(i) Making legislations that can reduce the bureaucratic process in building code administration to the code users to achieve regulatory goals (Imrie, 2004; Offei-Nketiah et al., 2019). Reducing the procedure of obtaining building permits, streamlining the implementation process, and regular inspection minimises bureaucracy within the building control system (Ametepey et al., 2015; Moullier & Krimgold, 2015). Meanwhile, Brian Easton (2012) pointed out that even though the legislations provide ways to reduce the bureaucratic process, some administrators could fail to implement it effectively.

(ii) Improving clarity and simplifying building code requirements increases the level of understanding (MBIE, 2014c, 2015, 2018c; B. Meacham, 2010b), especially as the practice of innovative techniques in performance-based building code is on the increase. The understanding of the building code requirements critically drives the success of the regulatory system (Moullier & Krimgold, 2015), when backed with adequate training regulations.

(iii) The flow of information and excellent communication between the code users and the regulators are essential to enhance building code improvement (GBPN, 2014; May, 2005; MBIE, 2018c; Moullier & Krimgold, 2015; Raman, 1997). The MBIE recognised that the regulatory system regarding monitoring and information flow is poorly managed (MBIE, 2015). The interaction among the stakeholders allows the regulators to hear the viewpoints of the regulated. This includes conducting technical meetings and workshops where the interest of both the regulators and the regulated are aligned to improve building code practice.

(iv) There is a need to conduct a practical impact assessment of the intended changes in the building code in line with the expected changes before the amendment, during the amendment process, and after the changes are in practice. Impact assessment promotes building quality, regulations, ensures efficient building performance (Michael Mills, 2010b), and correct the implementation of building code requirements (Chmutina & Bosher, 2015).

(v) The introduction of performance-based building code encourages the use of innovative technologies in design, construction, manufacturing, and other related service delivery. The use of these innovative technologies to demonstrate compliance has become problematic(Duncan, 2005; Gann et al., 1998), as the building officials find it difficult to balance the new ideas with the building code requirements (Duncan, 2005). Hence, providing legislative policies that could monitor and govern the use of these innovative approaches becomes vital as a measure to improve the use of building code. The effectiveness of these regulations would span across the people that use the technologies; the process followed to achieve the purpose of innovative technologies, the performance of the overtime, the planning phase, and the products that are used to acquire the results. The products designed with innovative techniques should undergo checks to ensure conformity with the construction system (Gann et al., 1998).

11.4.2. Design and implementation

Building code, to some extent, centres on the design and implementation of code requirements, which provides an insightful, practical application of building requirements. The implementation of building code requirements is often neglected as a result of the complexity surrounding code requirements (Coburn & Spence, 2003). It involves the participation of all relevant stakeholders to achieve a purposeful building code implementation through continuous training to ensure competency, technical assistance by experienced technical experts and regular active monitoring (Ricciarini Sylvana, 2009). Hence, effective implementation and design of building regulations depend on how the following measured criteria are improved, as discussed below:

(i) Overcoming the complexities within building requirements needs the involvement of competent technical staff who can review plans, inspect, monitor, and supervise the activities of the building code users (Chandel, Sharma, & Marwaha, 2016; Jones & Vasvani, 2017b; Moullier & Krimgold, 2015; Spence, 2004). Engaging the service of professional technical staff promotes the building regulatory system and guides the code users in the right direction. Besides, qualified technical staff detects violation within the building code and provide ways of correcting them. Effective design and implementation take place in an environment with sufficient skilled and competent staff with adequate legal, financial and moral support to function independently(Burby, May, et al., 1998; Offei-Nketiah et al., 2019; Yates, 2002b).

(ii) Encouraging low-risk innovative technologies in complying with the building code reduces the stress imposed on the building officials who review and inspect technical drawings and work constructions. Accordingly, using low-risk innovative techniques tends to balance the safety measures and possibly prevents difficulty in building code compliance and eases the code interpretation process on the side of the building officials (Duncan, 2005; Duncan John, 2000).

(iii) There is a need to enhance building quality and the incentives given to the code users, as these encourage implementation of building code requirements and building performance (David Kelly, 2012; MBIE, 2015). Offering incentives to good code practitioners ensure that buildings are constructed with adequate quality and performance to induce compliance (Burby, May, et al., 1998; Michael Mills, 2010b). The incentives could occur in diverse ways such as technical assistance (Burby, May, et al., 1998), relaxed inspection with leniency on violators (Burby, May, et al., 1998), waving of some fees, reduced administrative, bureaucratic process, training, and commendation awards.

(iv) Providing building code users with attractive technical assistance encourages compliance with less policing and a waste of resources on enforcement. Technical support increases the understanding of building code requirements and provides informative guidelines that help to attain building code objectives (Burby, May, et al., 1998; Haberecht & Bennett, 1999; Nwadike & Wilkinson, 2020a). Acknowledging the significance of providing technical assistance (Moullier & Krimgold, 2015) advised on institutionalising sustainable technical support to code users.

(v) Another way of improving the building code efficiency is by reducing the complexities within the building regulatory system, especially the building code requirements (David Kelly, 2012; Dixit Amod & Esteban Leon, 2009; MBIE, 2015; Nwadike & Wilkinson, 2020a). Building code complexities within the regulatory system could lead to poor design and implementation of code requirements, deficiency in building performance, and waste of resource in ensuring compliance (David Kelly, 2012; Gülkan, 2001; Listokin & Hattis, 2005; Michael Mills, 2010b; Nwadike & Wilkinson, 2020a).

11.4.3. Enforcement

Within the context of improving building code, improved enforcement becomes a necessity with measured criteria. These criteria are designed to establish a standardised enforcement process that ensures an effective voluntary enforcement mindset among the code users. Some of these criteria are well discussed below.

(i) Building code enforcement is best achieved when there is increased monitoring and inspection of building work regularly with shortened processing time (Michael Mills, 2010b; Moullier & Krimgold, 2015; Offei-Nketiah et al., 2019). The inspection and monitoring should revolve around assessing building plans before granting a permit, during different construction stages and final construction commissioning of the project (Awuah, Hammond, Lamond, & Booth, 2014).

(ii) Although promoting voluntary enforcement increases the building performance, encourages code users to comply, and provides the best regulatory practice. There is a need to have a mixed method of enforcement, as some building code users could misunderstand the basis for voluntary enforcement (Nwadike et al., 2019c). The mixed-method of compliance should be monitored, inspected, with adequate punishment for regular violators (Burby & May, 2000; Burby, May, et al., 1998), as it helps to deter non-compliance (Balch, 1980).

(iii) Enforcing building code requires a mechanism that ensures sufficient resources available for both the code regulators and the enforcement entities (Yates, 2002b). These resources could be in terms of sufficient skilled personnel, financial resources, logistics, smart regulations, and appropriate detection strategy (Offei-Nketiah et al., 2019; Olshansky, 1998; Spence, 2004; Yates, 2002b). Hence, improving the building code requires strengthening the resource availability for building code enforcement teams to avoid building deficiency and poor building performance.

(iv) Accordingly, the efficacy of building code enforcement depends on the ability of the enforcement team to have a well-defined enforcement strategy to detect and correct violation practices (R. J. Burby, P. J. May, E. E. Malizia, & J. Levine, 2000; Spence, 2004). It is essential to engage the services of qualified professionals in the enforcement team, as successful building code enforcement entails the use of mixed-method of enforcement, comprising of the systematic method (i.e. deterrence) and facilitative approach (i.e. voluntary). Furthermore, mixed-method enforcement becomes necessary as the application of one method comes with some unintended disadvantages (Burby, May, et al., 1998; Downs, 1991; Elliott, 1981; Nwadike et al., 2019c).

(v) Institutionalising a legal action plan with varied degree of punishments for building code violators could be another measure to deter people from violating the code provisions. The action plan will provide the enforcement team with an opportunity to assess the level of non-compliance based on the violator's efforts to comply and the associated impacts to determine the type of actions to be followed.

11.4.4. Compliance

It is crucial for relevant stakeholders to consider building code compliance in an attempt to improve building code. Effective building code compliance unlocks productivity opportunities through the code users within the building regulatory system (MBIE, 2018c). Furthermore, compliance with the building code requires an enabling environment supported with a legislative policy that is inclusive and allows for the participation of all stakeholders with encouraging incentives while empowering the building regulators to publish violators and reward compliance culture. Compliance with building code within the context of this study is measured under the criteria discussed below.

(i) Developing a mechanism to enhance understanding of building code provision is essential, and this can be achieved through improving code readability, simplifying code language, providing a detailed description of the minimum standard and providing education on the regulatory system through a well-communicated platform (Abimbola Olukemi Windapo & Keith Cattell, 2010; MBIE, 2018c; Shoichi Ando, 2008). Understanding the requirements of the building code helps people to comply easily.

(ii) One of the key elements that have demonstrated an increase in building code compliance is technical assistance. This is evident as Abimbola Olukemi Windapo and Keith Cattell (2010) cited lack of knowledge on code provisions as a major source of non-compliance. Enhancing technical assistance promotes compliance by educating the users while eliminating obstacles that could cause non-compliance with the building code among the code users.

(iii) Creating awareness on the need for compliance, consequences of non-compliance, advantages of complying with building code requirements, and how to comply are necessary as it equips the code users with a better understanding of why building code compliance is non-negotiable. Raising awareness allows the building code users to appreciate the benefits of compliance while increasing their interest to comply willingly (Huisman, Elffers, & Verboon, 2006; Johnson, 2011). Delivering building code awareness requires systematic training of the code users on various pathways to achieve compliance and efficient building performance (Abimbola Olukemi Windapo & Keith Cattell, 2010; Ahmed et al., 2018; APN, 2017b; Duncan, 2005; Meres et al., 2012). Improving building code requires a legislative policy that can create an enabling environment that can foster awareness, training, and its significance.

(iv) The desired fundamental principle of building code compliance is to inspire the code users to comply with the code provisions willingly without applying the deterrence enforcement approach (Burby, May, et al., 1998; Murphy, 2017). Considerably, this could be achieved through the medium of incentive rewards to those that willingly follow the stipulated rules. Incentive rewards encourage compliance with building code, especially as innovative techniques in performance-based building code poses a challenge to complying with building code. However, incomplete incentive rewards potentially lead to poor compliance (MBIE, 2015).

(v) Cost-benefit assessment on building code requirements is essential as it shows the cost implication of each code requirement (Arlani & Rakhra, 1988; David Norman, Matthew Curtis, & Ian Page, 2014). Glaeser and Gyourko (2003) reported that some building code requirements are expensive to comply with while insisting that some of the regulations are introduced into the building code without adequate quantification of the associated cost. Hence, these mean extra unnecessary financial cost for the code users. Within the above context, conducting effective cost-benefit analysis becomes a necessity to improve compliance with the amended requirements.

(vi) Regular building code amendment provides a means to make changes in the code through the introduction of new guidelines, requirements, setting new performance criteria, alterations, and safety measures. Amending building code helps the regulatory system to keep pace with innovative industrial ideas, emerging construction methods and to meet the modern-day societal needs (MBIE, 2020b). Adopting amended building regulation encourages compliance with the building code requirements, saves cost, minimises liability, and creates the need to train code users (NCBCS, 2018b). Improving building code requires the regular amendment process to incorporate new changes established through research findings, the knowledge gained through disaster, observed experience, and industrial gained knowledge.

11.4.5. Amendment process

It is crucial to consider the building code amendment process in improving building code requirements. The amendment process is unique in providing an opportunity for all relevant stakeholders to participate and make adequate contributions to improve the building code. The amendment process ensures that new innovative practices and products are introduced into the building regulatory system at the right time (Thompson, 1947; Vaughan & Turner, 2013). A successful amendment process helps the code regulatory system to continuously deliver better, smarter, and cost-effective buildings that serve society needs (Vaughan & Turner, 2013). New Zealand building code (NZBC) has passed through several amendment processes (Nwadike & Wilkinson, 2020a); however, improving the amendment process becomes necessary as the regulatory system sees several innovative techniques, new construction methods, and technologies emerge over time. In this context, some measured criteria are discussed below:

(i) The improvement of building code requires increased transparency, fairness, inclusiveness, openness, and balancing the interest of all relevant stakeholders (Nwadike & Wilkinson, 2020a; Vaughan & Turner, 2013). Transparency in the amendment process allows all the stakeholders to view all the activities taking place and fully participate in the process. Increased transparency strengthens the amendment process while given attention to all the suggestions from the stakeholders (Vaughan & Turner, 2013). Therefore, a transparent process in amending building code should be greatly encouraged as it protects the building code integrity regarding accuracy, competence, and completeness (Brown, Stern, Tenenbaum, & Gencer, 2006; Vaughan & Turner, 2013).

(ii) A well-managed and transparent building code amendment process is recognised (Nwadike & Wilkinson, 2020a); however, implementing the contributions from the stakeholders is significant in improving the building code. The stakeholder's contributions reveal the needs of the building sector and various ways to make building code compliance much easier to achieve (MBIE, 2019j). Hence, to achieve efficient building code improvement, the contribution of the stakeholders must be justified and balanced with the outcomes of the building code amendment process.

11.5. Proposed framework design and validation

This paper presents a framework design developed based on several studies conducted within the New Zealand building code regulatory system. Figure 11.1 shows the proposed framework design. The primary aim of the proposed framework design is to aid in improving the New Zealand building code and secure a safe built environment. However, the proposed framework will be validated through conducting interviews with the subject experts matter. This method of data collection is useful in validating frameworks as it seeks to acquire evidence to measure the construct of the subject topic under consideration (Angell, 2017).

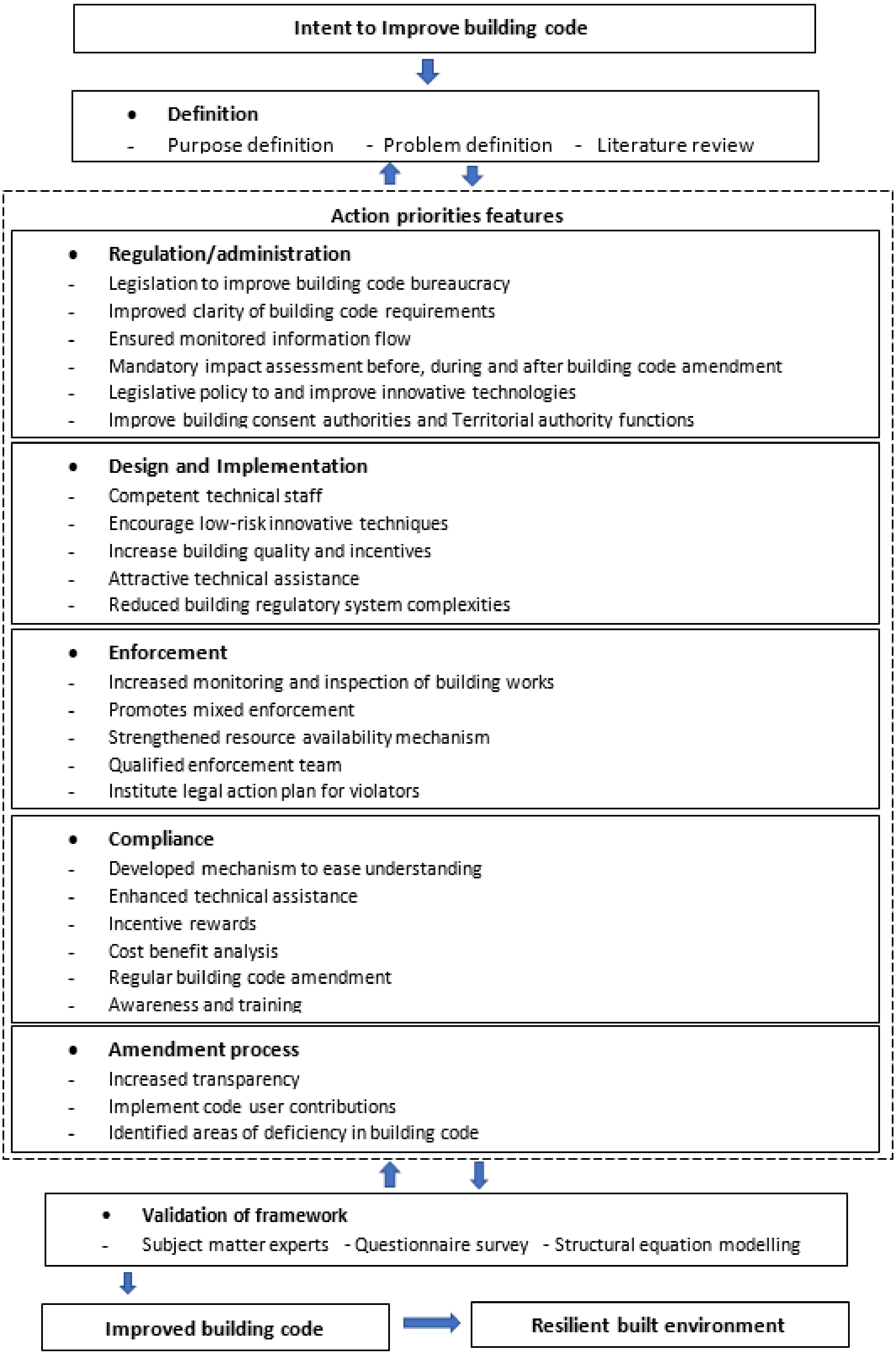


Figure 11.1: Framework design logic.

11.6. Discussion

This paper presents a proposed framework design developed to improve the New Zealand building code based on the identified parameters within the areas of concerns in the building regulatory system. These parameters consist of five action priority features such as regulation and administration, design and implementation, enforcement, compliance, and amendment process. Each action priority features are associated with criteria in the framework that works together to improve the building code, as shown in Figure 11.1. The concept of building code improvement is significant in providing a safer built environment, as the entire system is experiencing rapid innovative technologies, new construction methods, noticeable code deficiency, new construction materials while hazard occurrence is consistently increasing in the built environment. These necessitate the need to develop a framework to improve the existing building code.

The efficacy of the proposed framework depends on how the action priority features and the criteria are effectively implemented. The regulation and administration of the priority feature aim to create a legislative environment that promotes code clarity, bureaucracy, information flow, innovative technologies and improved functions of the subordinate regulatory authorities. Also, the priority feature of design and implementation aims to improve the application of building code requirements through skilled staff, calculated innovative techniques with attractive technical supports that minimises code complexities. Furthermore, the enforcement aspect of the action priority ensures that all regulatory rules and code requirements are strictly followed to enhance building code through monitoring, regular inspection, encouraged voluntary enforcement with a technically skilled enforced team and adequate resource. Besides, building code compliance within this context aims to improve compliance pathways with appropriate training to ease understanding, technical assistance and incentives. Building code amendment seeks to provide a platform where the observed deficiencies and new ideas are incorporated into the building code based on the contributions of all the relevant stakeholders. The amendment process balances all aspect of the action priority features in the proposed framework design.

The building code improvement could face some barriers identified in the building regulatory system. Balancing the diversity interest of all the relevant stakeholders becomes a hurdle, as each group is faced with a peculiar interest to protect. Notwithstanding, the political influence in the decision-making process can not be ignored over building code regulatory choices of what should be changed and when it should be changed (Burby, May, et al., 1998; May, 2005; Offei-Nketiah et al., 2019). Also, constrain on resource availability for the building code improvement process could be challenging as the entire regulatory system is involved (May, 2005; Spence, 2004; Yates, 2002b). Most importantly, raising awareness, educating the stakeholders on the importance of code improvement, and consideration of stakeholder's contributions for implementation under a transparent system is essential in overcoming the identified building code improvement barriers. Awareness and education are vital as they could help to reduce stakeholders biased contributions based on their interest.

11.7. Conclusion

This study identified potential parameters that aided in the design formulation of a framework to improve the building code system in New Zealand. The main purpose of developing the framework is to guide the pathway of improving building code and other associated documents in meeting the primary purpose of the building code, the societal needs, reducing complexities and providing clarity on building regulation requirements. The proposed framework is necessary as it encourages the use of innovative technologies, construction method and materials in meeting code requirements and demonstrating compliance with careful examination of the associated risks. Also, the framework enhances code users training, proactive technical support system, reduced bureautic process, enforcement and compliance. The application of the developed framework is unique as it allows resourceful contributions from all the stakeholders on the way forward towards improving the building code. The developed framework is designed to be validated using a triangulation research method to demonstrate the unique features of the framework in improving building code. The framework consists of five action priority features that form the primary components of building code. All the action priority features have appropriate criteria that define what needs to be changed or included in the building code and regulatory system. The identified criteria guide the stakeholder's participation while offering opportunities outside the identified criteria. Hence, the features identified in the framework are flexible and can be applied within any context relating to building code improvement; however, it may require modifications. The identified parameters within the proposed framework facilitate inclusiveness based on a transparent process that allows stakeholders to make useful contributions while validating the framework. Furthermore, the framework balances the diversity of stakeholders interest to enhance the building code improvement.

However, limitations exist in the developed framework as the identified action priority features, and the criteria were based on the current challenges facing New Zealand building regulatory system, even though it is flexible. Also, the implementation of the framework may be subject to validation to ensure accuracy. The application of the proposed framework would facilitate a robust building code improvement while providing a better understanding of the code requirement and technical assistance to the code users. Also, it will encourage voluntary compliance with the building code to promote a safer built environment that will be resilient to any form of hazard.

12. Evidence-based framework validation for building code improvement in New Zealand.

This chapter was developed from Publication № 11, which has been submitted to *Engineering, Construction and Architectural Management*. https://doi.org/10.1108/ECAM-08-2020-0604. This chapter aims to answer the research question RQ5 and research objective RO11.

Abstract

New Zealand building code may be serving its purpose to an extent, and there is still a need to develop a framework to improve the use and application of building code for better building performance and services. This study aims to validate the identified parameters in the developed framework to improve building code practice in New Zealand. Subject matter experts (SME) interview was conducted with key stakeholders that use building code, standards, and other associated compliance documents to validate the designed framework to improve the New Zealand performance-based building code. The NVIVO software was used to analyse the contributions from the subject matter experts. The findings from this study establish the importance of improving the building code, and the efficacy of a validated framework helps to identify the areas with the most pressing needs within the building regulatory system. All the subject matter experts unanimously agreed on educating and training the building code users. Besides, the validated

framework will enable the policy decision-makers in the building regulatory system to promote the use of building code and the utilisation of its potentials in reducing disaster while increasing the built environment resilience. The study concludes that the designed framework will create more robust strategy implementations to enhance innovative solutions embedded in performance-based building code. Implementing findings from validating the evidence-based framework in this study would help and guide the building code policy regulators toward improving the New Zealand building code and encourage the building code users to comply with the building code requirements. This study contributes towards improving the practical use and application of the building code requirements by guiding the building code regulators on the expectation of the building code users in future building code amendments.

12.1. Introduction

Building code sets the minimum standards for the designs and construction of buildings to meet the performance requirements and ensure the safety of both occupants and the buildings. However, adequate implementation and compliance with the building code requirements help to address most societal, development sustainability and resilience issues within the built environment (Meacham, 2016; Nwadike et al., 2019a, 2019c). The building code provides an effective pathway in reducing disaster impacts in the built environment (Burby & May, 1999; Jerry Velasquez, 2016; Offei-Nketiah et al., 2019).

The paradigm shift from prescriptive-based to performance-based building regulatory system created opportunities such as the introduction of new ideas, construction methods, new design criteria, construction materials while questioning the competency of building professionals (Duncan, 2005; Meacham, 2016; Nwadike et al., 2019a; Vaughan & Turner, 2013). Within the context of building code transition to performance-based system, the quest to reduce the regulatory burdens, introduce the innovative practice and promote flexibility in the use of building code was among the primary reasons raised (Lundin, 2005; May Peter, 2003; B. Meacham, 2010b; Mumford, 2010; Nwadike et al., 2019a). The performance-based building code paved the way for the introduction of an alternative solution in the building control system in pursuit to achieve innovative technologies and flexibility features in building regulation. Although demonstrating compliance with innovative solutions in building code is still challenging (Nwadike & Wilkinson, 2020e). While the performance-based building code has presented better opportunities and breakthrough in building regulatory system, it has created some challenges with significant impacts, such as the leaky building crisis in New Zealand (Duncan, 2005; May Peter, 2003; MBIE, 2015; Meacham, 2016). Some of these challenges could be attributed to complexities in the building regulatory system and innovation outpacing the readiness of the building code regulators, building practitioners and the building sector in design and construction (B. Meacham, 2010a; Nwadike & Wilkinson, 2020e). Innovation outpacing readiness could be traced to lack of education, training, irregular monitoring and information flow, lack of clarity on building code, inadequate technical guidance and resources within the regulatory system (MBIE, 2015; B. Meacham, 2010a). The problems with performance-based building code are further exacerbated with recent policies that introduced environmental sustainability assessment and climate change concerns into the building regulations (Meacham, 2016).

In an effort towards providing solutions to the unintended consequences surrounding the use of performance-based building code, the MBIE started making changes to the building code on a bi-annual basis in 2018 to keep the building code up to the societal expectations and latest developments with clarity and consistency (MBIE, 2018b). Building code amendment helps the regulators proactively respond to the needs of the building sectors, society, and the manufacturers while creating enabling environment for the building professionals to deliver better buildings. Accordingly, recent changes in the building code make compliance much easier with better building code compliance pathways (MBIE, 2019i). However, improving the building code requires identifying the areas of deficiencies within the building code, standards and compliance documents. During the consultation, contributions from building code users should be backed with substantial evidence as proof of noticeable deficiencies in the existing building code. The evidence-based approach helps the building code regulators to assess the identified area of deficiencies and ascertain how to make improvements in the building code that is practicable for better building performance and quality.

This study validates an evidence-based framework to access building code improvement. Subject matter experts interview was conducted with key stakeholders that use building code and make policies within the building regulatory system. Findings from this study presented potential areas that need improvement in the building code and will serve as a guide to the building code regulators and policy decision-makers within the building regulatory system.

12.2. Review of Building Acts and regulations improvement in New Zealand

Before the establishment of the Building Act in New Zealand, there exist building legislation enacted in 1842 as a response to reduce the effects of fire. The impacts of the Wairarapa earthquake (Magnitude 8.2) and the 1888 Canterbury earthquake (Magnitude 7.1) made the early European settler recognise ground shaking in the building legislation (Nigel Isaacs, 2011). The building legislation was gradually adopted by different provincial councils starting from Auckland in 1854 to New Plymouth in 1867 (Nigel Isaacs, 2011). Furthermore, Raupo House Ordinance was later introduced as an additional measure to reduce fire effects in Auckland to replace thatch roofs. It was progressively extended to other provincial councils in New Zealand before been repealed in 1878. As developments and hazards events unfold, many building ordinance and bylaws emerged in New Zealand, such as Auckland city Building Act 1854, New Plymouth Thatch and Straw Building Ordinance 1858, Otago-Dunedin Building Ordinance 1862, Canterbury-Christchurch Fire Prevention Ordinance 1867, and Local Building Bylaw in 1876 (Nigel Isaacs, 2011).

Down the line, New Zealand had over 60 Acts and Bylaws by 1979 administered by different government departments and municipal authorities. In 1986, there was a growing desire to have a coherent national building control regime in the building industry. The 1990 reform of building controls report paved the way for a new national performance-based building regulation system under a single Building Act (Nigel Isaacs, 2011). The Ministry of Business, Innovation and

Employment (MBIE) is responsible for reviewing and maintaining the building code activities as the lead policy advisor to the government on issues relating to the building regulatory system (MBIE, 2017g).

12.2.1. Building Act 1991

The recent development in New Zealand building regulatory system started with the enacting of the Building Act 1991, which was implemented in 1992. The Building Act 1991 converted the New Zealand prescriptive building code to performance-based, loosely derived from the Norwegian model. The performance-based building code allows flexibility and encourages innovative techniques in design and construction. It specifies the functional requirements and performance criteria for all building works in New Zealand built environment. The performance-based building code became mandatory in January 1993 (Haberecht & Bennett, 1999). The Building Act addressed the safety, health and wellbeing of building users and sustainable development in the built environment. The reviewed Building Act established the Building Industry Authority as the central monitoring agency while different municipal authorities perform the building control functions, respectively. However, the high expectation from the Building Act 1991 was cut short with the discovering of building deficiencies related to weather-tightness tagged leaky building (Hunn et al., 2002; Murphy, 2003). The weather-tightness issue became the only fundamental reason for unsatisfactory performance-based building code in New Zealand (Murphy, 2003). The Hunn report revealed the role of the government and the building industry in the leaky building saga (Hunn et al., 2002; Michael Mills, 2010b). The reactions from the public towards the Hunn Report compelled the government to restore public confidence in the building sector by setting up the Weathertight Homes Resolution Service Act 2002 (Samasoni, 2017).

12.2.2. Building Act 2004

In response to the systematic failure within the building regulatory system, the need to make technical changes and introduce the needed improvements in the building control system, the Building Act 1991 was repealed and replaced with the Building Act 2004. The new Building Act tightened up the noticeable inadequate regulatory policies and practice within the building regulatory system (Murphy, 2011). According to Michael Mills (2010b), the Building Act 2004 was introduced primarily in response to the leaky building issue. However, the Building Act 2004 was gradually introduced and implemented in stages alongside the repealed Building Act 1991 between 2005 and 2012 (MBIE, 2004). Also, the Building Industry Authority established under the Building Act 1991 to monitor the building industry performance was dissolved under the Building Act 2004. The primary aim of the Building Act 2004 is to provide enhanced consumer services by improving the building control system and encourage better building design and construction practices (MBIE, 2004). The aim focused on fine active features, according to MBIE (2004); (i) clearly set out the expected standards that buildings should meet. (ii) providing guidance on how to meet the standard requirements. (iii) ensuring that competent professionals are undertaking the design, construction and inspection process before approval. (iv) careful examination of the building consent and inspection process before approval, and (v) ensure homeowners are protected through mandatory warranties.

With recent advancement in performance-based building code, the MBIE announced the review of the Building Act in 2009 to ensure that the Building Act serves the purpose for which it was enacted. The review of the Building Act 2004 offered an opportunity to minimise compliance cost without compromising the building construction quality, provide clarity and reduce the bureaucratic process (Matthew, 2009; Murphy, 2011; Williamson, 2010). Also, there was a clear need to balance between the control measures, risk level and the competency and responsibility of the building professionals involved in building practices (Williamson, 2010). The purpose of reviewing the Building Act 2004 are summarised in (Matthew, 2009; Murphy, 2011; Williamson, 2010).

12.2.3. Building Amendment Acts 2012

The Building Amendment Act 2012 was the outcome of the comprehensive review of the Building Act 2004 between 2009 and 2010, aimed at improving the building performance and strengthening the building industry. The primary purpose of enacting the Building Amendment Act 2012 was to provide an improved building performance and establish a licensing system for the building practitioners. Furthermore, the amendment promoted accountability across the relevant stakeholders that are responsible for building code compliance. The Building Amendment Act 2012 becomes necessary as it focuses more on the safety of the people who use the building, even in case of fire incidence. The amendment ensures that sustainable development in the built environment is achieved through effective design and construction of adequate buildings.

12.2.4. Building Amendment Act 2016

The Building Amendment Act 2016 specifically targets earthquake-prone buildings in New Zealand. The amendment made changes to the methodologies on how local councils, building professionals and building owners handle earthquake-prone buildings. The Building Amendment Act 2016 came into force in 2017 to basically prevent death and reduce risks associated with earthquake-prone buildings (Langstone, 2016). Amendment to the existing legislation became necessary based on the identified lack of consistency in local practice, poor information flow pathway relating to earthquake-prone buildings and noticeable failure of the central government to provide guidance on earthquake-prone buildings. The Building Amendment Act 2016 divided New Zealand into three seismic risk categories, namely high, medium and low risks based on the location vulnerability, using the seismic hazard factor. The amendment sets the criteria for earthquake-prone buildings and developed a national timeframe for procedures relating to earthquake-prone buildings (Nick, 2016).

12.3. Promoting building code improvement in New Zealand

New Zealand's performance-based building code has undergone several changes and is still changing to ensure efficient building performance and quality under any condition. The long-standing focus of New Zealand on earthquake resiliency and consistent earthquake impacts make it imperative for regular improvements in the building code (Duncan, 2005; Meacham, 2016; Nwadike & Wilkinson, 2020e). Also, innovative techniques and flexibility in design and construction have pushed for improvement in the performance-based building code (Nwadike &

Wilkinson, 2020e). Regular updates of the building code produce better, smarter and cost-effective buildings (Vaughan & Turner, 2013), that can increase resilience in the built environment. Improving the performance-based building code requires creating an enabling environment that could drive the needed changes and foster the implementation of code requirements within the building regulatory system. The desired enabling environment could be in the form of provision of incentives, proactive training, technical guidance, resources availability and reduction of building code complexities. Jones and Vasvani (2017b) noted the relevance of competent building consent professionals in promoting building code improvement. Promoting building code improvement requires the active participation of all key stakeholders within the building regulatory system. Also, it ensures that building code reaches the point where it can deliver the built environment that meets the society and building code users expectations, respectively.

12.4. Framework development for building code best practice

This section presents an evidence-based framework designed to improve the building code and create an enabling environment to promote performance-based building code practice in New Zealand, as shown in Figure 12.1. The evidence-based framework was developed and designed based on intensive qualitative and quantitative research studies (Nwadike & Wilkinson, 2020a, 2020b, 2020e; Nwadike et al., 2019a, 2019c; Nwadike & Wilkinson, 2021). The primary goal of the developed framework is to achieve a resilient, built environment through efficient building code practice. The framework described the processes involved in the use of the developed evident-based framework in chronological order. The action priorities identify criteria parameters that require active drivers and key relevant stakeholders contribution towards improving the building regulatory environment to foster code users best practice. The criteria section provides details of each action priorities, and it is linked with the arrowheads in the framework. The contributions are evaluated using an evidence-based approach. The criteria stage describes the specific areas that need improvement within the building regulatory system. The action plan offers potential strategies to achieve the primary goal of building code through adequate information dissemination and awareness, appropriate consultation, involvement, collaboration and sufficient assistance to the building code users.

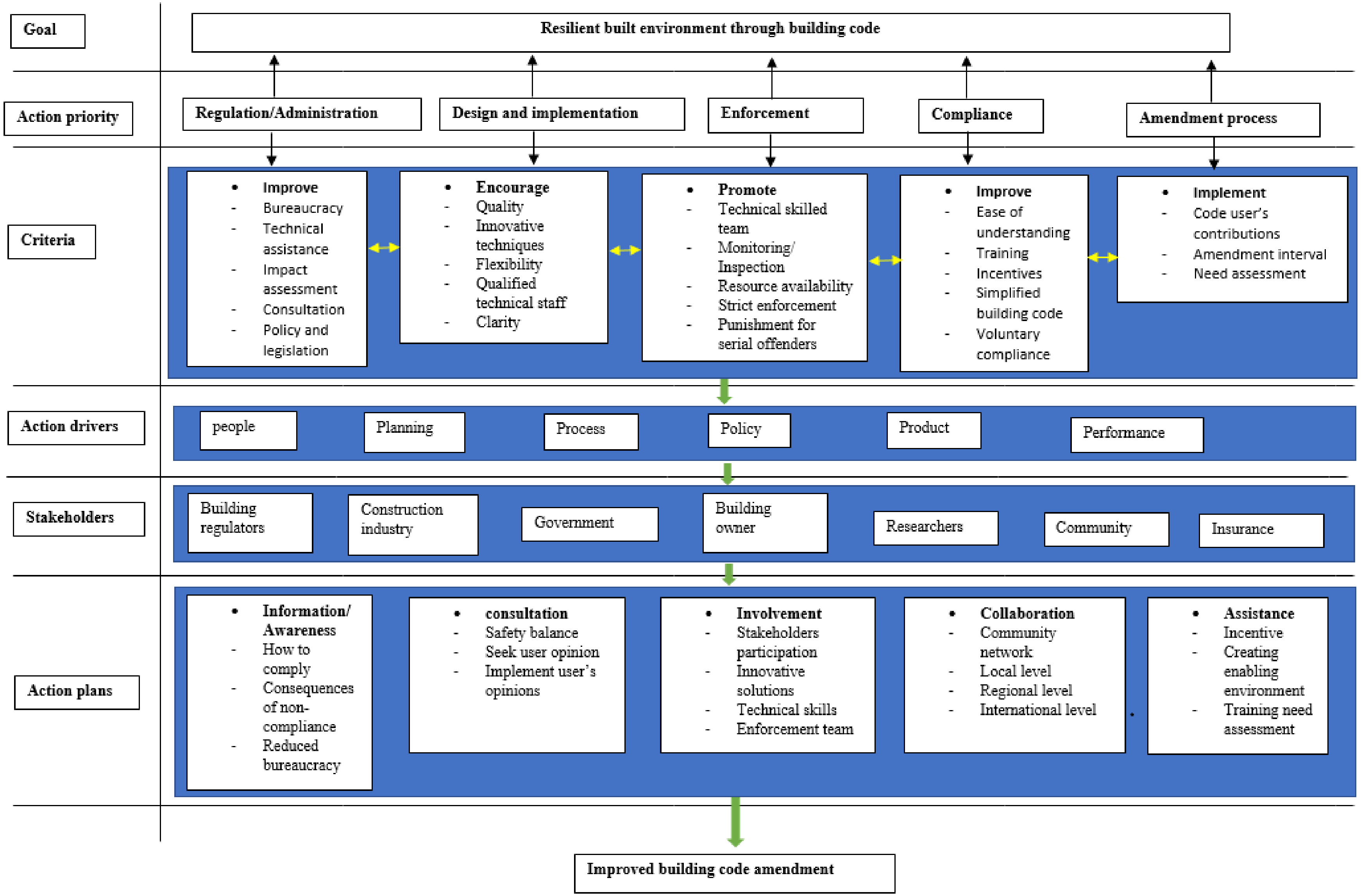


Figure 12.1: Evidence-based framework development.

12.5. Research method

This study aims to validate a framework to improve building code practice in New Zealand. The framework ensures better building quality and efficient building performance. To achieve the aim of the study, Subject Matter Experts (SME) was adopted to validate the framework with relevant stakeholders to explore their expert knowledge, critical industry experience and relevant opinions regarding the study topic (Bill, 2020; Egbelakin, 2013; Larmore, 2011). A subject matter expert is an individual who has sufficient skills, knowledge and experience within a particular field (Hopkins & Unger, 2017). The SME approach was selected as it is cost-effective and provides sufficient information on a subject matter (Evan, 2018). Also, the SME helps to examine the practical implications and applicability of the developed framework to improve building code practice in New Zealand. The SME approach allows the selected participants to ask questions for more details and clarity.

12.5.1. Data collection

Nine electronic interviews were conducted with relevant stakeholders to validate a developed framework by exploring their individual opinions, respectively, in improving building code practice in New Zealand. With this study context, the electronic interview is the use of electronic communication facilities to communicate with participants in a video or audio format. The interview with the SME was conducted during the COVID-19 pandemic, hence the use of the electronic interview method to maintain appropriate physical distance. The quality of the electronic interview entirely depends on the technology device and internet connection between interviewer and interviewees (Deakin & Wakefield, 2014). Each interview lasted for approximately 45 to 75 minutes. According to Creswell and Poth (2018), the number of interview participants varies between 5 and 30 participants based on these two main reasons, (i) their advancement in knowledge of the research problem under investigation and (ii) the semantic saturation point of the interview emerging themes. Accordingly, Umar and Egbu (2018) opined that six interview participants are adequate for qualitative study provided the participants gives useful facts in the subject area. The SME was selected as the adequate data collection method as it provides unrestricted opportunities to the participants to make contributions based on their experience. The subject matter experts were selected using purposeful sampling techniques, as it allows the selection of individuals with vast knowledge on the subject matter to offer meaningful and insightful details (Babbie, 2013; J. A. Maxwell, 2013; Neuman, 2014). All the SME's are in top positions in their various companies and organisations, actively using the building code. The selected SME's are regarded as the most suitable individuals to contribute toward improving the building code. One of the primary criteria used in selecting the SME's were that each of them must have practised at least ten years with the New Zealand building code in New Zealand and must have actively participated in the MBIE building code amendment process. The interview participants are characterised by both the building code users and the regulatory authorities, which provides equilibrium for a better validation of an evidence-based framework. Also, the willingness of the intended participants and their confidence level in responding to interview questions were fully considered (Marshall, 1996).

The process of selecting the SMEs involves searching through contributions and reports made towards New Zealand building code amendments through the MBIE, local authorities across New Zealand, technical groups such as the Building Research Association of New Zealand (BRANZ) and personal contacts in technical meetings and conferences. The selection criteria were used to screen each individual, and those deemed to have satisfied all the criteria were contacted. In total, 123 SMEs were found during the searching process and after careful application of the selection criteria, 55 SMEs were contacted, 21 SMEs agreed and indicated their interest, 7 SMEs disagreed to participate due to personal reasons, while 22 SMEs did not reply or respond to the email and 5 emails did not go through. However, only 9 SMEs were interviewed. The interview process was stopped at the point where semantic saturation point was reached, and no new emerging themes in the interview were observed (Creswell & Poth, 2018). The SME's were approached individually using their email address, and upon their acceptance, a convenient date and time are scheduled. To maintain anonymity in this study, each interview participants were given a code such as SME 1 to SME 9, respectively, as shown in Table 12.1.

Table 12.1: The participants profile.

SME's	Position description	Years of experience
SME 1	Principal Partner (Technical)	About 30 years
SME 2	Senior Structural Engineer	Over 25 years
SME 3	Senior Technical Planner	About 35 years
SME 4	Senior Structural Engineer and University Professor	More than 35 years

SME 5	Senior Engineer	Over 15 years
SME 6	Senior Technical Assessor (Building consent capability)	About 23 years
SME 7	Principal Technical Assessor (Building consent capability)	Over 30 years
SME 8	Director, Earthquake Engineering New Zealand and Senior Technical Advisor, Department of Building and Housing	More than 40 years
SME 9	Chief Engineer (Structures)	About 30 years

12.5.2. Data analysis

A qualitative data analysis software called Nvivo was adopted to analyse the data obtained from SME interviews. The qualitative data analysis involves a five-stage process of transcribing and preparing data, data organisation, data familiarisation, themes creation and assigning of codes, and data sorting to identify main themes in each category from the data obtained. Furthermore, a three-step code process was used in NVIVO for this study, as explained in (Jackson & Bazeley, 2019; Johnny, 2009; Jørgensen & Jensen, 2011; McNiff, 2016; Richards, 2002). The first step coding process identifies the essential contributions to knowledge; the second step summarised the contributions through a pattern of the coding process, while the third step identifies the overarching theme in each category. The interview recordings were manually transcribed for better accuracy despite its time-consuming nature of interviews and considering the number of participants and the quality of the audio recordings.

12.6. Applicability of the designed framework

The study participants were used to explore the practical application and validity of the developed framework in improving building code practice in New Zealand. To ensure meaningful contributions from participants, the study identified five categories called action priority features, with each category having criteria under them. This process involves the use of Nvivo software in the analysis.

12.7. Results and discussion

This section reflects on the data gathered from the contributions of the SME's. The SME's gave their individual opinions on the various ways of improving the New Zealand building code. Based on the SME's opinions, five themes were identified as discussed below.

12.7.1. Building code regulation and administration

The regulations guiding performance-based building code and standards are regularly subjected to change, either as a result of disaster impacts or an understanding gained through technology and innovation to improve the application of building code and built environment resilience (Brian Meacham et al., 2005; Nwadike & Wilkinson, 2020e; Nwadike et al., 2019c). All the SME's believes that improving the New Zealand building code requires an improvement in the regulation and administrative process of building code. SME 1 pointed out that some of the difficulties experienced in the administrative process of building code are because councils sometimes struggle to provide adequate services to all as a result of many requests for building services, especially in the smaller councils. This could be because of an insufficient number of technical personnel within the council. The central government may need to step in to help smaller councils with adequate personnel and financial resources. The intervention from the central government to small councils is necessary as the building code regulation ensures that buildings are constructed to meet the societal expectations in design, construction, building quality and performance. A primary theme that emerged during the interview was bureaucracy. This is significant as it deals with the process of obtaining the building permit, consent, and inspection. According to SME 8, "you get people calling to get their building consent in time, my reaction is always that I rather have a good building consent that is late than a different building consent that is on time and this is because buildings are around for a long time". Furthermore, SME 2, SME 4, SME 6 and SME 9 believes that bureaucracy in New Zealand building code is at a low level when compared to other countries using performance-based building code. SME 8 pointed out that a moderate bureaucratic process is necessary under performance-based building code as more time is needed for thorough and competent checking of building applications to ensure all buildings complies with the building code requirements. Others acknowledged the need to drastically reduce the bureaucratic process within the building control system. However, SME 4 said that the bureaucratic process could be improved by hiring competent technical staff at all levels in the building regulatory system in New Zealand. Also, SME 1 suggested having a national procedure for all councils to follow in processing building consent applications to ensure a consistent system.

Bureaucracy within the building regulatory system could be because of the application of innovative techniques in providing building solutions in design and construction. The innovative solutions may be more problematic where it is not completely understood by both the building consent officers and the building code users (Duncan, 2005), and maybe a contributing factor to bureaucracy. Hence, the importance of legislative policy to guide and improve the use of innovative techniques in performance-based building code was well highlighted. SME 5 acknowledged that building consent officers in New Zealand are keen on new innovative solutions compared to other countries, as it benefits the project outcome. Although, SME 8 was of the opinion that "the government and the regulatory authorities are careful in promoting certain innovative technologies or products because a lot of people will want to have their product in the building code".

The need for improved clarity in building code requirements was overwhelmingly mentioned by all the SME during the interview. This is important as the demand for innovative solutions and regular changes surrounding building code and standards are on the increase among the code users to enhance best practice. Although the New Zealand building code clauses are subjected to consistent restructuring to enhance clarity, however, more clarity is needed to achieve societally acceptable building performance and quality. For instance, the building code requires code users to achieve a bare minimum standard; however, the definition of the bare minimum standard remains questionable as the code users struggle for greater understanding and specificity to code requirements. Hence, SME 6 opined that improving clarity in the building code requires good education, not training for better interpretation of building code requirements. SME 8 noted the need to simplify building standards such as the concrete standard. Also, SME 4 stated that "the current building code says that a building shall have a low probability of failure, but that does not tell you what a low probability of failure is and how to achieve that; hence I will like to see the probability of failure defined in the building code". Defining the low probability of failure will play a major role in boosting better building performance, enhance understanding and productivity in the building industry.

12.7.2. Design and implementation

Understanding building code requirements and implementing them in design and construction remains a significant aspect of the building control system. Design and implementation become significant as performance-based building code only states the building performance without a systematic procedure on how to achieve this requirement. This is exacerbated as society expects more than what the building code could offer. According to SME 1, "there is a big difference between the public and building code regulators perception as the public expects buildings to perform very well during any extreme loading conditions and not just be there to save lives, whereas the philosophy of the building code has been that as long as lives are being saved, it does not matter if a building has been written off".

Design and implementation of building code require competency from both the code users and the building consent officials that will assess, review and inspects building plans. SME 9, SME 5, SME 8 and SME 1 emphasised the need for councils to employ competent professionals that are technically skilled to review building applications. The competency of the building consent officers should be periodically assessed since the building code is regularly amended. Also, the assessment is necessary as a performance-based building code encourages innovative designs and construction. SME 6 stressed that building code could be improved by having competent technical staff through educating and training of council staff and code users. SME 1 added that building code users and the building consent officers should be trained to design buildings for resilience rather than life safety.

In encouraging effective design and implementation of building code requirements, the subject matter experts were divided on encouraging low-risk innovative solutions in the use of building code. Although performance-based building code is flexible and allows the use of innovative techniques in design and construction, SME 8, SME 6, SME 9 and SME 5 believes that promoting the low-risk innovative practice in the use of building code could help to improve building performance and quality. Furthermore, SME 6 added that innovation could only be encouraged if effective training and education precedes any changes in the building code and standards. However, SME 4, SME 1, SME 7, SME 2 and SME 3 argued that innovation is what makes performance-based building code unique and hence should be encouraged as it yields better building performance and quality, especially during and after extreme loading conditions. Innovative solutions bring an element of risk in design and construction; however, the building code users have to determine how to achieve compliance with the building code. Also, the users of such innovative techniques have to assess whether the risk associated with such an innovative solution is acceptable or unacceptable. SME 4 remarked that designs with extreme innovative techniques carry a higher level of risk compared to normal designs. However, many could argue this assertion as it may not always be the case. Additionally, SME 4 states it clearly that "a low-risk design is never going to be innovative and innovative design carries risk". Hence, SME 9 concluded that encouraging a low-risk innovation is necessary as it makes building code compliance more difficult. Also, SME 8 called for an improved building code where the code will recognise how the low-risk innovation can be delivered and set the performance requirements so that it can be used.

New Zealand building code is unique in encouraging and allowing innovative methods through the pre-application process where the code users can interact with the council building consent authorities on the planned innovative approach and how compliance with the building code requirements could be achieved. This process is well appreciated, as the code users have the opportunity to demonstrate compliance with the building code. Almost all the subject matter experts agree that the council building authorities accept innovative solutions, but demonstrating compliance could be challenging. Therefore, improving innovative solutions in building code requires building consent authorities and code users that have vast technical knowledge in the use of alternative solution provided within the building control system. Also, applying innovative solutions requires consistent monitoring and adequate expertise to ensure innovative ideas does not lead to a problem. SME 1 suggested incorporating suitable risk management practice in the application of innovative solutions to minimise any associated risk effectively. In general, SME4 acknowledged that the issue with the building control system is that the performance-based building code, in theory, is good in allowing innovation but needs improvement to achieve it in practice. It is obvious that the argument for low-risk innovative techniques could be based on the incidence surrounding the innovative practice in the leaky building issues in 2002.

Promoting effective design and implementation of building code requirement requires providing adequate technical assistance to the code users. All the SME's unanimously agreed that providing technical support to the code users would improve the use of building code. However, who pays for the services becomes an issue to be considered, said SME 9. SME 9, SME 8, SME 2 and SME 6 affirmed that although the council building authorities tend to provide technical advice, they do not stand by their advice in terms of implementation. This is because the council building authorities are not allowed to offer interpretations on building code requirement, as such, can not be held accountable. Hence, offering technical guidance requires a change of policy that will enable the building to consent authorities to provide supportive advice to the code users. It further requires building consent officials who are confident of the kind of support they provide, skilled and competent staff, an adequate number of building officers and resource availability within the council to offer such expensive services. Also, SME 6 clearly stated that "having a good system of technical support in place in the absence of a good education may not necessarily work as expected". Presently, BRANZ offers free technical assistance to industries but not free for individuals.

Provision of an attractive free to low-cost technical guidance to the code users becomes essential as New Zealand is using a performance-based building code surrounded with complexities. The Ministry of Business Innovation and Employment regularly improves the building code, standards and the associated compliance documents to simplify and provide a better understanding of building code to the code users. However, SME 5 opined that recent changes to the building code seem to make the code requirements more complex. One of the dominant factors that emerged during the interviews in reducing building regulatory complexities from all the SME's is that even though simplifying the building code is essential and widely accepted, such should be done in a manner that will still allow the building code to deliver the expected results. Besides, complexities within the building regulatory system could be reduced by enabling the right people with the required technical competency to make policies that are practically achievable with adequate capacity to govern the building regulatory system. SME 8 said that complexities within the building regulatory system could be reduced by having individuals that are familiar with the building industry at the policy decision-making levels. Also, SME 8 ascertained that "a look into the staff directorate at the Department of Building and Housing (DBH) just after the Canterbury earthquake shows zero personnel with experience in design and construction, two charted professional engineers other than the chief engineer, eleven lawyers, twenty-two chief executive officers and forty-four people in the policy section without adequate knowledge of building control system".

12.7.3. Building code enforcement

Another theme that emerged during the interviews is the need to improve the building code through the enforcement process. This is necessary to ensure reduced disaster impacts in the built environment. All the SME's acknowledged the role of increased monitoring and inspection of building works in promoting enforcement. Effective monitoring and inspection boost building performance and building quality. SME 9 pointed out that regular monitoring and inspection of building projects forces code users to comply with the building code requirements. However, effective monitoring and inspection require the availability of resources. Lack of sufficient resources within the enforcement agencies to carry out their activities could lead to passive enforcement and non-compliance (Burby, May, et al., 1998; Nwadike et al., 2019c; Yates, 2002b). Hence, the apex regulatory body should empower the councils to provide adequate services in enforcing building code requirements. Additionally, SME 8 said, "I strongly think that the building regulatory system including the councils are under-resourced, and it simply indicates that technical building code issues such as enforcement do not matter". Accordingly, SME 8 hinted that the Building Industry Authority (BIA) was underfunded, which created a major problem in educating and training the code users after the New Zealand building code was converted to performance-based building code. Furthermore, enough time and resource are spent in developing and amending the building code; however, little is spent in training and creating awareness, said SME 8.

Enforcement becomes essential as the innovative techniques embed in performance-based building code presents challenging situations to both the building officials that assess and enforce the building code requirements and the code users that apply the building code requirements. Furthermore, achieving building code enforcement requires training code users and providing all the necessary supports, said SME 6. Providing such needed supports and services help the code users to comply easily. SME 6 noted that many code users are trying to follow and comply with the building code, but many lack the required knowledge.

A leading factor in the enforcement discussion is the need to have qualified enforcement personnel. Qualified enforcement teams have the skilled capacity to evaluate, detects and correct any building code and standard violations. The adverse effects of neglecting the use of qualified building officials in enforcing building code could significantly present a barrier towards efficient building code improvement.

Considering the option of instituting a legal action plan for violators, all the SME's agreed to this but further pointed towards the direction of preventing such design and construction from taking place. Although there are severe punishments for building code violators, it is in the best interest to have a good monitoring and inspection team to stop the bad works before it is being carried out. SME 8 and SME 1 believes that the approach of waiting to react after the code users are allowed to violate the building code requirements is a wrong approach and does not help because the buildings have already been built sub-standard. Therefore, empowering the code users to design and construct buildings properly is better than taking legal actions. SME 1 suggested that the government and the building industry should promote a better building material procurement system and ensure that design-build type of projects are well monitored as they can breed non-compliance with the building code. This is necessary as this type of construction puts pressure on the code users to cut-corner for profit rather than building efficiently. The government should engage code users based on building quality, resilience and performance.

12.7.4. Building code compliance

The need to improve building code compliance came up as one of the key themes during the interviews. A common solution suggested by all the SME's is to provide proactive training supports and making sure that all the code users are aware of the building code amendments, including the building standards and other associated compliance documents. SME 1 added that "getting good compliance with the building code, you need the right incentive, and without good incentives, you will struggle to get good compliance". According to SME 8 and SME 5, compliance can be easily achieved when the cost of complying with the building code is reasonably convenient for both the code users and the clients. Cost of compliance with the building code becomes an issue where it exceeds the cost of non-compliance (Burby & May, 2000; Burby, May, et al., 1998). Also, the cost of demonstrating compliance, if not checked, could limit the use of innovative solutions in design and construction (Levi-Faur, 2011; May Peter, 2003). There is where the code users, clients and the building code regulators need to have some form of integrity, as the New Zealand regulatory system have an adequate check and balance to ensure improved building quality, said SME 4. Hence, SME 1, SME 8, SME 3, SME 7 and SME 2 called for effective cost-benefit analysis and impact assessment before making changes to the building code and standard. The cost of compliance is on the client while the benefits are to the society, said SME 1.

Promoting compliance with building code in a situation where the building code, standards, and associated compliance document undergoes regular amendments require developing a mechanism to ease understanding of the changes and enhancing the technical assistance offered to the code users. This deals with improving building code readability, simplifying the code terminologies, increase usability and making the building code more user-centred while enhancing clarity in the building code requirements. Also, incentives to the code users can not be neglected. This is significant as SME 8 firmly believes that one of the issues with amending building code is that it might take 2 to 3 years to sink into the people. The MBIE funds over 120 building standards and made them available for free downloads in the quest to remove all intended and unintended barriers to compliance with the building code (MBIE, 2019f). This move was necessary as the building professionals are concerned that the cost of compliance could make it challenging to comply with the building system.

12.7.5. Building code amendment process

The amendment process allows all the stakeholders involved with building code to make meaningful contributions to building code improvement. During the cause of the electronic interviews, 88.88 per cent of SME's mentioned the need to improve the building code amendment process, even though the MBIE has an open policy in amending the building code. Open consultation with building code users requires increased transparency on the part of the building code regulators. SME 5 and SME 8 pointed out that the current building code amendment process is already transparent, while SME 5 further stressed that transparency might not even solve any problem. SME 1 believes that "the amendment process would be better if it starts from the bottom up and consults with the people who are on the frontline designing buildings, constructing buildings and looking at previous building performance under earthquake". The transparent process would encourage the code users to participate in making changes in the building code.

Two leading factors observed during the interviews could improve the amendment process: Firstly, the need to find out from the frontline building practitioners what are the issues with the current building, standards and the associated compliance document before opening the doors for consultation. SME 1, SME 6, SME 3 and SME 2 further hinted that this step is essential as most people involved in regulating the building code do not use the building code in practice. This is true as the building practitioners use the building code daily and understand the issues and what needs to be improved. SME 1 believes that sometimes the consultation may be asking the wrong question because the authorities have not made inquires from the building professionals. Secondly, the need to have people with the right technical expertise at various levels of decision-making positions with sufficient fundings and enabling environment that is without bias. Based on the above leading factors, the building code regulators can facilitate the process by formulating an evidence-based framework for the amendment process. Also, the building regulators will handle the feedbacks, making changes, maintaining and updating the building code and standards, said SME 1.

Another challenging issue surrounding the building code amendment process is implementing the contributions from the building code users. These contributions need to be evidence-based before they can be considered. According to SME 8, contributions from social groups are more likely to be considered compared to individual contribution. SME 8, SME 7, SME 4, and SME 6 believes that the building code regulators implement code users contributions to a larger extent, while SME 1, SME 9, SME 5, SME 2 and SME 3 are of the opinion that to a greater extent the building code regulators do not implement code users contributions. For instance, SME 1 said, "They had this amendment process last year, and there was a lot of comments, and we don't know what happens to it". Some of the evidence-based contributions that are not implemented could be traced to lack of confidence on the part of the building code regulators, said SME 8. Hence, establishing a confidence-based relationship between the code users and the code regulators is needed to drive adequate building code improvement in New Zealand.

12.8. Conclusion

This study explored how the New Zealand performance-based building code could be improved using the opinions of SME's. The viewpoints of the SME's was used to validate an evidence-based framework on building code improvement. The contributions from all the SME's aligned with the need to improve the existing building code, especially as the country is using performance-based building code, faced with active seismic challenges that could impact the built environment resilience. Building code and building standards improvement promote building performance, quality and clarity on building code requirements.

Findings from all the SME's during the interviews revealed the leading factors in improving building code, standards and other related compliance documents as follows: (i) the need to reduce bureaucratic process in administering building code services. (ii) the necessity of having competent technical building officers who can rightly review building applications. (iii) improving clarity in building code requirements to reduce complexities, especially defining the bare minimum standards recommended in the building code. (iv) although the SME's were divided in encouraging low-risk innovative techniques, all their contributions point towards promoting reasonable innovative solutions that are achievable and in line with the building officers and code users knowledge. (v) proactive training, educating, attractive incentives, awareness and providing adequate technical assistance to the code users. (vi) enabling individuals with the required technical competency at different building policy decision-making levels of the building regulatory system. (vii) establishing an active enforcement process with qualified personnel adequate monitoring and inspection of building works rather than waiting for legal actions against the building code violators. (viii) sufficient resources for councils and building consent officers, especially smaller councils that may not afford the resources necessary to provide building services. (ix) encourage regular building code amendment centred on user friendly with an intent to ease compliance with building code.

The findings from this study revealed that both the building code users and the building authorities have to step up in improving the use of building code. Also, the results from the study presented a useful background for a better understanding of the dominant factors that need improvement in the building code regulatory system. These findings serve as a guide to the building code policy regulators regarding the existing building code and the expectations of the code users in future amendments. Implementing the findings in this study has created opportunities for future pursuits by the policy regulators and researchers within the performance-based building code environment. Also, the findings from this study may not be generalised to the global context but could be transferred to the nations that use regularly reviewed performance-based building code, standards and other related compliance documents within the range of New Zealand building code amendment interval. As a limitation, the present study used only contributions from SME's to validate the designed evidence-based framework, future works should consider using a mix of quantitative research approach to repeat similar or same study. Also, this study could be repeated with a more significant number of SME's, with improved SME's selected criteria. Furthermore, future researchers in this area should consider converting the designed framework into a computerised format and expand the framework. Since the training of building code users was mentioned by all the SME's interviewed, it is needful for further researchers to formulate a step by step approach in training building code users, especially considering the knowledge of the code users in order to provide a specific training scheme. Also, during the course of the study, questions regarding how to balance the innovative practice within the performance-based building code. Hence, future research will fully address this question.

13. Summary and recommendations for future research

13.1. Summary

With the increasing changes made in the building code, standards and compliance documents, and the noticeable effects of the introduction of performance-based building code, this thesis has explored the impacts of building code amendments in the New Zealand built environment. The thesis developed and validated an evidence-based framework based on identified parameters and provided strategic measures for building code improvement. The original contribution of this research to the body of knowledge, building code regulators, building code users and a summary of the research objectives are outlined. Also, the research recommendation, research limitation and future recommendation are presented below.

13.2. Original research contribution

This thesis contributes to the existing body of knowledge on the impacts of performance-based building code amendments. This study focuses on improving the identified issues surrounding the building code practice within the building regulatory system. Also, the study addressed the use of innovative solutions and their related barriers in performance-based building code practice. The contributions of this study are outlined and discussed below.

13.2.1. Theoretical contribution

The significant theoretical contribution of this paper is the development of an evidence-based framework for building code improvement. The evidence-based framework offers a valuable theoretical contribution to the body of knowledge by presenting the challenges and improvement measures to establish a better performance-based building code practice. The study findings establish the necessities of regular building code amendment and its urgency in New Zealand as the country is located in an active seismic environment. This study demonstrated with empirical evidence that there are significant impacts associated with amending performance-based building code. Most of these impacts are as a result of the innovative solutions and flexibilities surrounding performance-based building code. Also, the outcomes from this study align with the existing literature on performance-based building code and the building regulatory system, as the thesis used integrative literature review, document analysis, closed-ended questionnaire and interviews with subject matter experts in its analysis.

13.2.2. Contribution to the building code regulators

This study addressed the current issues surrounding New Zealand building code and various ways of making resourceful changes for better use and application of the building code requirements toward a sustainable built environment that can truncate hazard from turning into a disaster.

Innovative solutions were identified in the study findings as a source of complexities in performance-based building code. The findings in this study inform the building code regulators on how to handle issues arising from the innovative techniques through engaging experienced technical professionals in reviewing building applications and creating an environment that will encourage a knowledge-based and reasonable use of innovative solutions in design and construction. Also, the result advised the building code regulators on the need for systematic transferring of established innovative practice from concept to practical-based innovative solutions in making changes to existing building code. Training building code users are essential to improve the use of innovative solutions in design and construction.

Introducing a two-step consultation process before building code amendment were emphasised in the research findings. The two-step consultation process helps the building code regulators to present the right questions to the code users. The first step involves consultations with all the technical group heads, while the second phase consultation is opened to all the building code users for evidence-based contributions. However, exploring the opinions of building code users helps to capture the code users pressing needs rather than implementing the decision-makers concepts.

The outcome of this study revealed the impacts of building code amendments. Following regular changes to the building code, standards and compliance documents, the research findings in this study inform the building code regulators on the unintended consequences after building code amendments. This is important because, without adequate knowledge on the unintended consequences, implementation of the benefits of building code amendment may be limited. Minimising the impacts of the unintended consequences following building code amendment requires providing awareness, active training and effective technical guidance to the building code users. Furthermore, these research findings advised the building code regulators on the significance of three years amendment interval against the present biannual amendment process. The recommended amendment cycle helps the building code users learn and implement the changes in design and construction. At the same time, it offers the decision-makers ample time for better consideration before making decisions. Also, it promotes compliance with the building code requirements and reduces the impacts of building code complexities. The study findings identified parameters on pressing areas in the building code, standards and compliance documents that need to be changed. The developed evidence-based framework for building code improvement will guide the building code policy-makers while allowing for meaningful contributions from relevant code users and balancing the stakeholder's diverse interest. The developed framework creates robust implementation strategies that would enhance the use of innovative solutions in design and construction.

13.2.3. Contribution to the building code users

This study indicates the need to provide an enabling environment that can ease compliance with the building code requirements while minimising the associated challenges arising from building code amendment. Considering the application of innovative solutions in design and construction, the study findings advised the building code users on the necessities of applying reasonable innovation that is achievable and measurable to the knowledge of the building consent officers for a proper review of building applications. Both the qualitative and the quantitative study findings revealed the need for the building code users to engage in training programmes on implementing and complying with the building code requirements actively. Different technical groups could organise these active training programmes under the building regulatory system to augment the required skills. The study findings educate and broaden the understanding of the building code users on the impacts of regular building code amendment practice and their respective responsibilities in reducing the impacts. The study findings recommended the active participation and meaningful contributions of all the building code users in improving the building code, standards and compliance documents.

13.3. Review of research objectives

The predominant focus of this study is to address the impacts of regular building code amendments and identifying various ways of how it can be improved for better practice and a resilient built environment. This study developed five research questions and eleven research objectives. A summary of how this study achieved each research objective is outlined below.

Objective one: To assess the contextual background of building code.

An overview of the first research objective is addressed in Chapter two of this thesis. The contextual background of building code was reviewed by studying the international perspective of building code history, performance-based building regulations, issues that necessitates building code enforcement, and the paradigm shift from perspective-based to performance-based building code. The findings in this context offered a fundamental description of reasons why performance-based regulations have gained global attention as it presents strategic measures for disaster risk reduction, allows innovative techniques, encourages regulation amendments, and improved building resilience an earthquake and other related extreme loading conditions in the built environment. Also, the review identified difficulties in demonstrating compliance (alternative solution) without any reliance on prescriptive solutions (acceptable solution). The findings revealed the need for regular and effective building code amendment while noting that non-amendment of building code is a disaster on its own.

Objective two: To explore the impacts of innovative techniques in performance-based building code.

This research objective two was adequately addressed in Chapter three. Exploring the innovative techniques offered by the performance-based building code revealed the benefits and the unintended consequences of innovation in the building regulatory system. The integrative review found that innovative techniques provided the opportunities for the introduction of new concepts in terms of new designs, construction methods, better building quality and flexibilities in the building sector to encourage implementation that drives the building industry. Also, the study disclosed some of the unintended consequences surrounding the use of innovative techniques as it centres on how to verify innovative solutions to achieve compliance, fear of liability on the side of building officials and inadequate training of the code users. Unsupervised innovative techniques could affect the safety clause in the building code. Hence, technical guidelines to the code users and building officials, proactive training and innovative impacts analysis are recommended. Further, this study argued for adequate preparation and enabling environments where ideas can drive before introducing new concepts in the building regulatory system.

Objective three: To explore the process of New Zealand building code amendments.

Chapter four of this thesis provides the answer to research objective four. An integrative review into the New Zealand building code amendment process and timelines revealed the need for improvement as it would help to address non-compliance with the code requirements. Although the amendment process is well-managed to an extent, however, there is a need for improved training and technical assistance to the building code users after the amendment process. It is imperative to have an enabling environment where transparency and inclusiveness drive with the active participation of all relevant stakeholders to create a mutual relationship between the code regulators and the regulated. Also, it was found that factors that push for building code amendment depend on location, the type of building code in use and society needs. However, the study findings demonstrated that there are post-amendment challenges that need to be addressed, such as building code complexities, lack of training, awareness, inadequate enforcement and non-compliance with the new changes in the code requirements.

Objective four: To examine the code user opinion in building code amendments.

Research objective four were explicitly answered in Chapter five of this study. The investigation into the viewpoints of building code users regarding building code amendments in New Zealand showed that the code users shared different opinions on some issues surrounding the building regulatory system, such as amendment intervals, access to amended documents, and method of communication. A high proportion of the surveyed participants showed agreement on a three years amendment cycle against the current biannual amendment practised at the moment. Although the study noted the quest to ensure continuous safety and improvement to achieve a resilient built environment could make it difficult for a three years amendment interval. Therefore, the building code amendment interval should be designed to allow for an appropriate time for learning and implementation before the next amendment cycle to ensure compliance with the updates. The study affirmed the necessity of building code amendment and support for increased free availability of amended building code, standards and compliance documents to the public. The findings relating to the building code opinions on the code amendment aligns with existing literature and practices in some countries.

Objective five: To examine the benefits of building code amendments.

This research objective five was achieved in Chapter six of this study. Investigating the benefits of regular building code amendment shows that it is a step in the right direction. Building code amendment yielded significant results in improving resilience, compliance level, flexibility in design and construction, quality of construction and reduced corruption tendencies. However, without providing free to low-cost technical assistance to the code users, reducing bureaucratic process, and raising awareness on the importance of building code amendment, the full benefits of regular building code amendment may not be achieved as it mostly involves incorporating innovative techniques offered in the performance-based regulation. The findings also advised on the need to promote local technology without altering its local creativity. The study highlighted the need to recruit experienced building officials who could offer assistance to code users. Hence, promoting capacity building becomes necessary to achieve the objectives of building code amendment in New Zealand.

Objective six: To explore the unintended consequences of building code amendments.

Chapter seven revealed the answer to research objective six in this thesis. Research findings on the New Zealand building code amendment show that there are unintended consequences of amending the building code. This includes a shortage of technically skilled building officials knowledgeable in the new changes, inadequate training to match the changes, delayed design and construction approvals, and increased technical complexities within the code requirements. It was found that the negative impacts of building code amendment affect the level of compliance and the associated financial implications. Some of the unintended consequences noticed could be as a result of poor planning in the building regulatory system, the approach towards innovative solutions and flexibilities within performance-based building code.

Objective seven: To investigate the challenges facing building code compliance after amendments.

The answer to objective seven was provided in Chapter eight of this research. Making changes in the building code stirs challenges towards compliance. The study findings showed that inadequate compliance features, insufficient enforcement, education and awareness before and after building code amendment are among the most pressing challenges. Although building code compliance becomes challenging when the cost of compliance is much higher than the cost of non-compliance. These findings agree with existing literature (Burby, May, et al., 1998). However, corrupt practice within the building regulator system was at a deficient proportion in the New Zealand context. The study concludes on the necessity of reducing complexities surrounding building code compliance which may have originated from the regular building code amendments.

Objective eight: To identify the effectiveness of building code compliance in improving resilience.

Chapter nine of this thesis addressed the research objective eight in this study. Improving disaster resilience in the built environment requires effective compliance with the building code. Effective building code compliance is achieved through a multi-party collaboration where all relevant stakeholders are fully carried along. Hence, the study developed a framework that incorporates the functions of different stakeholders to ensure compliance. To this extent, a practical approach to capacity building development within the regulatory system is essential to enhance practice that encourages compliance. Also, the findings demonstrated the significants of a mixed method of fostering compliance, including enforced and voluntary. The study highlighted the features that drive voluntary compliance and how they can motivate code users to comply with code requirements. Besides, the findings indicated that before encouraging voluntary compliance, there is a need to ensure a reduced compliance cost, sufficient stakeholders consultation, skilled building officials who can detect and correct the violation, and adequate socio-political considerations.

Objective nine: To examine factors that encourage building code compliance.

Research objective eight was answered in Chapter ten of this thesis. In examing the importance of encouraging stakeholders to comply with building code requirements and identifying the factors that drive compliance, the study developed a framework. The established framework balances the diverse interest of the stakeholders. The research informs the building policy regulators on how to increase compliance with clearly defined stakeholders functions. The study findings revealed that implementing the identified 6Ps factors create an environment that fosters compliance. However, the study pointed out the need to balance the application of innovative technologies, quality of construction material and safety in building code amendments on the scales of compliance, as this help to select a low-risk innovative approach that can easily demonstrate compliance.

Objective ten: To identify the parameters required for building code improvement.

This thesis answered the research objective ten in Chapter eleven. This study developed an evidence-based framework based on the identified parameters, which include action priority features and criteria to improve the building code. The developed framework will guides the building policy-makers in the decision-making process while balancing the stakeholder's diverse interest. This study offered an opportunity to improve building code through stakeholders collaborative efforts based on inclusiveness and transparency. The objective of the evidence-based framework is aligned with the purpose of the MBIE in ensuring an improved building code to keep pace with innovative solutions in the modern design and construction methods practised globally. This study identified all the necessary parameters to improve the use of performance-based building code in the New Zealand context.

Objective eleven: To validate an evidence-based framework for building code improvement.

Chapter twelve of this thesis addressed research objective eleven. This study validates the developed evidence-based framework for building code improvement using contributions from the subject matter experts that use and regulate the building code. The study findings revealed the efficacy of promoting and encouraging reasonable innovative solutions that are achievable based on the knowledge of the building officials and code users. Also, the study findings firmly advised for active enforcement team with vast technical experience on effective monitoring and inspection of building works instead of waiting for stop-work-order or taking legal actions against violators. Therefore, improving the New Zealand building code, standards and other related compliance documents promotes building performance and quality while reducing the impacts of seismic challenges in the built environment. The findings in this study further advised the building code policy decision-makers on the necessity of implementing a 2-step consultation: (i) the need to consult with some selected relevant frontline building code practitioners on the areas in the building code, standards and compliance documents that require improvement. This procedure helps to ask the right questions in the second stage of the consultation. The selected relevant building code users should comprise representatives of various technical groups and organisations within the building regulatory system. (ii) opening second consultations where the building code users and the general public are allowed to make contributions. The implication of the developed evidence-based framework is that it fosters inclusiveness while pressing towards the robust implementation of strategies that will achieve building code primary objectives. Also, the evidence-based framework offer opportunities for building code users to make meaningful contributions that could improve the use of building code and create an enabling environment for building code users.

In summary, the thesis explored the benefits, unintended consequences and various ways of improvements associated with building code amendment which intends to promote the use of building code and enhance building resilience in New Zealand built environment. The study recognised the significants of innovative technologies in performance-based building code; however, the study recommends precautionary measures in its application as it could increase the challenges confronting the use of performance-based code in disaster risk reduction. This study provides a platform that allows the policy-makers and the stakeholders to interact on issues within the building regulatory system and offered explicit directions that encourages code users to comply with the building code requirements. The research identified areas that need improvement through existing contextual literature, questionnaire survey and subject matter experts.

13.4. Research significance

This research added values to the body of knowledge by addressing the impacts of building code amendments and how the unintended consequences of the amendments can be improved to increase building resilience against extreme loading conditions. The research significance is demonstrated in its contributions in bridging the practical and theoretical knowledge gaps surrounding the New Zealand building code amendments and its measures to reduce disaster impacts. This research considered improving the impacts of regulating building code to increase the rate of compliance with the changes in the building code.

Contributions from this dissertation formed a basis that can assist building code policymakers, researchers, local authority councils, government, and building professionals researching on mitigating disaster impacts using building code, regular amendments and improving code compliance in the built environment.

This research made new theoretical and practical contributions to the body of knowledge as outlined below:

(i) Insightful accounts into the contextual background of building code and amendments as a measure to mitigate disaster impacts globally with an emphasis in New Zealand built environment;

(ii) Improved understanding of innovative techniques in performance-based building code, its impacts on safety measures and how it can be applied to improve building resilience;

(iii) Development of a well-defined building code amendment process that encourages consultation and participation with a capacity to integrate all relevant stakeholders diverse interest, hence, providing logical outcomes;

(iv) Understandings of the role of public funding in promoting the retention of heritage buildings in New Zealand's provincial regions

(v) Better understanding of the benefits of regular building code amendment with an emphasis on improving building resilience, training of code users, quality of construction, compliance, enforcement and innovative technology;

(vi) An enhanced Understandings of the unintended consequences of building code amendments, their causes, and how they can be handled to improve building code usability. It informs the building code regulators on practical procedures to ameliorate its impacts and the need to provide mitigating measures before amending building code;

(vii) Identification of challenges facing building code compliance, caused by building code amendments with recommended proactive approaches to handle the challenges to increase the level of code compliance;

(viii) Demonstration of a detailed understanding of the efficacy of building code compliance in improving resilience in the built environment;

(ix) Development of building code compliance framework that integrates the diversity of stakeholder's interest and encourages code users to comply with the amended building code;

(x) Insights into the developed framework based on identified parameters comprising of five action priority features with criteria for building code improvement to ensure better building performance and resourceful implementation of code requirements;

(xi) Validation of an evidence-based framework that integrates stakeholders contribution to building code improvement while balancing their interest diversities to enable better building code implementation and a resilient built environment.

13.5. Research limitation

While the findings in this study have provided solutions, guidance and recommendations for building code improvement, there exist some noticeable limitations surrounding the thesis. Some of the research limitations come from the regular building code amendment. This means that some of the identified building code impacts may change with respect to time. However, this limitation does not mean that the findings in this study are not relevant.

The response rate of the questionnaire survey shows that only the structural engineers made up to 50 per cent of the respondents, which could be viewed as unlikely the best but within the limits of the study. The difference in the professional representation may have little or no influence on the study findings as the study findings align with the existing literature within the building code sector. Also, the study used a Likert scale to analyse the respondent's perceptions of the impacts of building code amendments. There could be possibilities of bias based on the respondent's opinion. However, careful measures were taken to minimise this kind of limitation. Also, the study used 116 questionnaire survey respondents and conducted nine interviews with the SME's for analysis. This may not be good enough but within the required research limits.

The research data for this study were collected within a specific period. Budget and time constraint may have affected the ability of the researcher to conduct a longitudinal study on the New Zealand performance-based building code over a long period. Although this study focused on building code, the findings in this study were limited to social science and construction management aspect without any extension to the engineering aspect of the building code. Furthermore, the validation of the developed evidence-based framework is mainly dependent on the judgement of the SME's, which could be biased and suggest the possibility of uncertainties.

13.6. Delimitation

This thesis is only centred on the impacts of building code amendments in New Zealand. This research delimitation was set to ensure a concise and focused study. The participants in the data collection process of this thesis are strictly restricted to only the building code users and the building regulators. The description of the building code users and the building regulators is defined according to the New Zealand building code in this thesis. The rationale for this criteria is to ensure that only those with adequate knowledge of New Zealand performance-based building code participated in the data collection process.

13.7. Future research

The findings in this research have contributed significantly to the body of knowledge both in theory and practice within the building regulatory system in New Zealand, especially the impacts of building code amendments. The research findings opened many opportunities for future research suggestions and improvement.

Based on this research on the impacts of building code amendment, further research should consider streamlining how the impacts of building code amendments affect each stakeholder in the building control system with an emphasis on the construction industry. The impacts of innovative techniques in performance-based building code were examined, research on how to balance innovative techniques and safety in the building regulatory system to demonstrate compliance is recommended. Further benefits can be added by researching on how to provide equivalent training, awareness and technical support to the code users. Regarding the building code amendment process in New Zealand, new research should examine transparency, inclusiveness and various ways of filtering bias opinions in the amendment process to ensure active participation of all relevant stakeholders. Considering the current practice of biannual amendment interval in New Zealand, the findings in this study showed a high proportion of code users desire a three years amendment cycle. Hence, further research should assess the benefits of three years amendment interval and how it can be implemented in New Zealand to achieve over the borderline mark of biannual amendment interval. The benefits of building code amendment have been explored; further research should focus on developing a capacity-building framework to promote proactive training of the code users. Additionally, extended research into advancing local technology through building code amendment is required. The research findings show that building code amendment comes with unintended consequences in the building regulatory system; further research should examine the analysis of technical complexities within the building code and its impacts in the construction industry. Also, exploring how policy and legislation can offer an avenue to reduce the unintended consequences identified in this thesis is recommended as it will enhance resilience in the built environment.

Complying with building code requirements is significant; research into understanding the financial implications of building code compliance with an emphasis on the construction industry following building code amendment in New Zealand is recommended. The developed evidence-based framework for building improvement provides a pathway that guides all stakeholders, researchers and decision-makers when considering measures to improve the building code practice. A further upgrade of the developed evidence-based framework into a decision-making tool that involves a focus group workshop for all relevant stakeholders for deliberation could serve as follow-up research. Also, subsequent research could focus on advancing the developed framework into a computer-based model. Regular revision of the framework and reducing the time constraints in applying the evidence-based framework would remove any possible setback with the framework. The evidence-based framework in this study was validated using subject matter experts; further studies should validate the framework using the triangulation research method to validate the framework. The triangulation method could comprise of subject matter experts, questionnaires, and structural equation modelling. Also, further research is encouraged in using focus group workshops to validate the framework.

This thesis has provided a fundamental platform for policy-makers and code users in the building regulatory system. It is crucial to further research in this direction in providing resilience to the built environment as climate change and hazard occurrence are on the increase. Further research on mainstreaming building code into disaster risk reduction is necessary, with an emphasis on how the building industry understands and implement the code requirements to reflect in reducing disasters such as an earthquake. Further research should advance into enhancing the application of building code through the collaborative efforts of all relevant stakeholders.

References

ABCB. (2013). History of the National Construction Code. . Retrieved from http://www.abcb.gov.au/en/about-the-national-construction-code/history-of-the-ncc

ABCB. (2016). *National Construction Code: Building Code of Australia Class 2 and Class 9 Buildings*. Australia: Australian Building Code Board.

Abimbola Olukemi Windapo, & Keith Cattell. (2010). *A study of building contractors' compliance with national building regulations in Cape Town*. Paper presented at the RICS_COBRA, South Africa. file:///C:/Users/user/Downloads/CIB20060_RICS_COBRA_CONFERENCE_2010.pdf

Abimbola, O. W., & Keith, C. (2010). *A study of building contractors' compliance with national building regulations in Cape Town*. Paper presented at the RICS_COBRA, South Africa. https://www.researchgate.net/publication/286821693_A_study_of_building_contractors'_compliance_with_national_building_regulations_in_Cape_Town

Ahlbrandt, R. S. (1976). *Flexible code enforcement: A key ingredient in neighborhood preservation programming*: National Association of Housing and Redevelopment Officials.

Ahmed, I., Gajendran, T., Brewer, G., Maund, K., von Meding, J., & MacKee, J. (2018). Compliance to building codes for disaster resilience: Bangladesh and Nepal. *Procedia engineering, 212*, 986-993.

Aigwi, I. E., Egbelakin, T., & Ingham, J. (2018). Efficacy of adaptive reuse for the redevelopment of underutilised historical buildings. *International journal of building pathology and adaptation*.

Aigwi, I. E., Filippova, O., Ingham, J., & Phipps, R. (2020). Unintended consequences of the earthquake-prone building legislation: An evaluation of two city centre regeneration strategies in New Zealand's provincial areas. *International journal of disaster risk reduction*, 101644.

Aigwi, I. E., Ingham, J., Phipps, R., & Filippova, O. (2020). Identifying parameters for a performance-based framework: Towards prioritising underutilised historical buildings for adaptive reuse in New Zealand. *Cities, 102*, 102756.

Aigwi, I. E., Phipps, R., Ingham, J., & Filippova, O. (2019). Urban transformation trajectories of New Zealand's earliest cities undergoing decline: identifying links to the newly enforced building (earthquake-prone buildings) Amendment Act 2016 *43RD AUBEA*, 591.

Ainuddin, S., Mukhtar, U., & Ainuddin, S. (2014). Public perception about enforcement of building codes as risk reduction strategy for seismic safety in Quetta, Baluchistan. *International journal of disaster risk reduction, 9*, 99-106.

Ainuddin, S., & Routray, J. K. (2012). Community resilience framework for an earthquake prone area in Baluchistan. *International journal of disaster risk reduction, 2*, 25-36.

Alter, L. (2018). Building Code Changes Can Have Unintended Consequences. Retrieved from https://www.treehugger.com/building-code-changes-can-have-unintended-consequences-4851775

Ambraseys, N., & Bilham, R. (2011). Corruption kills. *Nature, 469*(7329), 153-155.

Ametepey, S. O., Ansah, S. K., & Edu-Buandoh, K. (2015). Assessing factors affecting implementation of the national building regulations (LI 1630) in Ghana. *Public Policy and Administration Research, 5*(2), 66-73.

Ang, G., Groosman, M., & Scholten, N. (2005). Dutch performance-based approach to building regulations and public procurement. *Building Research & Information, 33*(2), 107-119.

Angell, K. (2017). Using quantitative research methods to determine the validity and reliability of an undergraduate citation rubric. *Qualitative and Quantitative Methods in Libraries, 4*(4), 755-765.

Angrosino, M., & Mays de Pérez, K. (2000). Rethinking observation: From method to context I: Denzin, NK, 1941-, & Lincoln, YS Handbook of qualitative research, 2, 673-702. In: Thousand Oaks, CA.: Sage Publications.

Ansari, S., Panhwar, A. H., & Mahesar, G. A. (2016). Mixed Methods Research: Ontological, Epistemological and Methodological underpinnings. *ARIEL-An International Research Journal of English Language and Literature, 27.*

Anwar, N., Aliani, A. H., & Amatyakul, W. (2012). Integrating environmental sustainability and disaster resilience in building codes.

APEC. (2015). Green building code infrastructure guide. Retrieved from https://www.apec.org/Publications/2015/05/APEC-Green-Building-Code-Infrastructure-Guide

APN. (2017a). Understanding the opportunities and challenges of compliance to safe building codes for disaster resilience in South Asia. Asia-Pacific Network for Global Change Research. Retrieved from https://www.preventionweb.net/files/62325_crrp201709syahmedfinalreport3.pdf

APN. (2017b). *Understanding the opportunities and challenges of compliance to safe building codes for disaster resilience in South Asia*. Retrieved from Asia: https://www.preventionweb.net/files/62325_crrp201709syahmedfinalreport3.pdf

Arlani, A., & Rakhra, A. (1988). Building code assessment framework. *Construction Management and Economics, 6*(2), 117-131.

Armstrong, A., Wright, C., Ashe, B., & Nielsen, H. (2017). Enabling Innovation in Building Sustainability: Australia's National Construction Code. *Procedia engineering, 180*, 320-330.

Ashburton District Council. (2019). Building Regulation: ACTIVITY MANAGEMENT PLAN 2018-28. Retrieved from https://www.ashburtondc.govt.nz/SiteCollectionDocuments/Plans%20and%20Strategies/Activity%20Management%20Plans/Building%20Regulation.pdf

Atkinson, P., & Coffey, A. (2004). Analysing documentary realities. *Qualitative research: Theory, method and practice, 2*, 56-75.

Auckland Council. (2020). Building legislation. Retrieved from https://www.aucklandcouncil.govt.nz/building-and-consents/Pages/building-legislation.aspx
Awuah, K. G. B., Hammond, F. N., Lamond, J. E., & Booth, C. (2014). Benefits of urban land use planning in Ghana. *Geoforum, 51*, 37-46.
Babakus, E., & Mangold, W. G. (1992). Adapting the SERVQUAL scale to hospital services: an empirical investigation. *Health services research, 26*(6), 767.
Babbie, E. R. (2013). *The basics of social research*: Cengage learning.
Babrauskas, V. (2000). Performance-Based Building Codes: What Will Happen to the Levels of Safety? *Fire Science and Technology Inc*.
Baiche, B., Walliman, N., & Ogden, R. (2006). Compliance with building regulations in England and Wales. *Structural Survey, 24*(4), 279-299.
Baker, J. D. (2016). The purpose, process, and methods of writing a literature review. *AORN journal, 103*(3), 265-269.
Balch, G. I. (1980). The stick, the carrot, and other strategies: A theoretical analysis of governmental intervention. *Law & Policy, 2*(1), 35-60.
Baumeister, R. F., & Leary, M. R. (1997). Writing narrative literature reviews. *Review of general psychology, 1*(3), 311-320. doi:https://doi.org/10.1037/1089-2680.1.3.311
Beck, C. T. (1999). Facilitating the work of a meta-analyst. *Research in nursing & health, 22*(6), 523-530. doi:https://doi.org/10.1002/(SICI)1098-240X(199912)22:6<523::AID-NUR9>3.0.CO;2-9
Becker, R. (2008). *Fundamentals of performance-based building design.* Paper presented at the Building Simulation.
Beller, D. (2001). *Qualitative versus quantitative aspects of performance-based regulations.* Paper presented at the CIB World Building Congress, April 2001.
Beller, D., Foliente, G., & Meacham, B. (2003). Qualitative versus quantitative aspects of performance-based regulations. *CIB REPORT*, 383-394.
Benge, C. (2001). AN ARGUMENT FOR DURABILITY REQUIREMENTS IN BUILDING REGULATIONS. Retrieved from https://www.irbnet.de/daten/iconda/CIB2597.pdf
Bergeron, D. (2008). *Codes for existing buildings: Different approaches for different countries.* Paper presented at the Proceedings of the SFPE 7th International Conference on Performance-Based Codes and Fire Safety Design Methods, SFPE, Bethesda, MD.
Bergeron, D., Desserud, R., & Haysom, J. (2004). *The Origin and development of Canada's objective-based codes concept.* Paper presented at the Proceedings of the CIB Triennal Congress, Toronto, Canada.
Berry, K., & Kincheloe, J. (2004a). Rigour and Complexity in Educational Research. Conducting Educational Research. *Open University Press*.
Berry, K., & Kincheloe, J. (2004b). Rigour and Complexity in Educational Research. Conducting Educational Research. *Open University Press*, 208.
BHRRC. (2013). Rana Plaza building collapse, April 2013. Retrieved from https://www.business-humanrights.org/en/rana-plaza-building-collapse-april-2013

Bilham, R. (2013). Societal and observational problems in earthquake risk assessments and their delivery to those most at risk. *Tectonophysics, 584*, 166-173.
Bilham, R., & Gaur, V. (2013). Buildings as weapons of mass destruction. *Science, 341*(6146), 618-619.
Bilham, R., Gaur, V. K., & Molnar, P. (2001). Himalayan seismic hazard. *Science, 293*(5534), 1442-1444.
Bill, B. (2020). The Instructional Development Team: Subject Matter Experts. Retrieved from https://learningsolutionsmag.com/articles/the-instructional-development-team-subject-matter-experts
Bill, E., Simon, P., Steven, P., & Rodney, H. (2011). *Housing Affordability*. Retrieved from New Zealand:
Bill Millard. (2019). The International Code Council goes to court over free access to building codes. Retrieved from https://archpaper.com/2019/07/international-code-council-start-ups/
Bird, D. K. (2009). The use of questionnaires for acquiring information on public perception of natural hazards and risk mitigation-a review of current knowledge and practice. *Natural Hazards and Earth System Sciences, 9*(4), 1307.
Bolger, J. (2000). Capacity development: why, what and how. *Capacity Development Occasional Series, 1*(1), 1-8.
Bosher, L., & Dainty, A. (2011). Disaster risk reduction and 'built-in'resilience: towards overarching principles for construction practice. *Disasters, 35*(1), 1-18.
Bowen, G. (2009). Document Analysis as a Qualitative Research Method. *Qualitative Research Journal, 9*(2), 27-40. doi:10.3316/QRJ0902027
Bowen Glenn. (2009). Document Analysis as a Qualitative Research Method. *Qualitative Research Journal, 9*(2), 27-40. doi:DOI 10.3316/QRJ0902027
Bowen, R., & Thomas, R. (1997). TG11–Performance-based building codes. *CIB REPORT, 211*.
Boynton, P. M., & Greenhalgh, T. (2004). Selecting, designing, and developing your questionnaire. *Bmj, 328*(7451), 1312-1315. doi:10.1136/bmj.328.7451.1312
Brad Kelechava. (2017). 2018 International Building Code. Retrieved from https://blog.ansi.org/2017/11/2018-international-building-code-icc-ibc/#gref
BRANZ. (2004). Compliance path 8: Verification Methods. Retrieved from https://www.renovate.org.nz/regulation-compliance/compliance-paths/compliance-path-8-verification-methods/
BRANZ. (2014). Building a Better New Zealand: Annual Review 2014. Retrieved from http://www.branz.co.nz/cms_show_download.php?id=d8c85adfbf3b93682f89c4aaa59920183df26964
Brian Easton. (2012). Regulation and Leaky Buildings. Retrieved from https://www.eastonbh.ac.nz/2012/01/regulation-and-leaky-buildings/
Brown, A. C., Stern, J., Tenenbaum, B., & Gencer, D. (2006). *Handbook for evaluating infrastructure regulatory systems*: The World Bank.
Brown, N. (2017). Epistemology. Retrieved from https://www.nicole-brown.co.uk/epistemology/

Bryman, A. (2008). Of methods and methodology. *Qualitative Research in Organizations and Management: An International Journal*.
Buchanan, D. A., & Bryman, A. (2009). The organizational research context: properties and implications. *The SAGE handbook of organizational research methods*, 1-18.
Buckett, N. (2014). A code to build by. Retrieved from https://www.buildmagazine.org.nz/assets/Uploads/Build-142-49-Feature-Uniquely-NZ-A-Code-To-Build-By.pdf.
Build Waikato. (2019). Legislation. Retrieved from https://www.buildwaikato.co.nz/legislation-2/
Builderscrack. (2014). Changes to Building Amendment Act to Benefit Homeowners. Retrieved from https://builderscrack.co.nz/blog/project-advice/advice-other/building-amendment-act-changes-to-benefit-homeowners.html
Bullen, P. A., & Love, P. E. (2011). Adaptive reuse of heritage buildings. *Structural Survey*.
Bulmer, M. (2004). *Questionnaires*. Thousand Oaks, United States: SAGE Publications Limited.
Burby, R., & May, P. (2000). *Issues for regulatory enforcement and compliance with building codes: American perspectives*. Paper presented at the 12th World Conference on Earthquake Engineering, Auckland, New Zealand. http://www.iitk.ac.in/nicee/wcee/article/2558.pdf
Burby, R., May, P. J., Malizia, E. E., & Levine, J. (2000). Building code enforcement burdens and central city decline. *Journal of the American Planning Association, 66*(2), 143-161.
Burby, R. J., French, S. P., & Nelson, A. C. (1998). Plans, code enforcement, and damage reduction: Evidence from the Northridge earthquake. *Earthquake Spectra, 14*(1), 59-74.
Burby, R. J., & May, P. J. (1999). Making building codes an effective tool for earthquake hazard mitigation. *Global Environmental Change Part B: Environmental Hazards, 1*(1), 27-37. doi:doi.org/10.3763/ehaz.1999.0104
Burby, R. J., May, P. J., Malizia, E. E., & Levine, J. (2000). Building code enforcement burdens and central city decline. *Journal of the American Planning Association, 66*(2), 143-161.
Burby, R. J., May, P. J., & Paterson, R. C. (1998). Improving compliance with regulations: Choices and outcomes for local government. *Journal of the American Planning Association, 64*(3), 324-334.
Burgess, M., & Thomson, J. D. (2015). *National Construction Codes and Their Inadequacies: Australia's Arrangements and Difficulties.* Paper presented at the Proceedings of the 19th International Symposium on Advancement of Construction Management and Real Estate.
Byrne, J. A. (2016). Improving the peer review of narrative literature reviews. *Research integrity and peer review, 1*(1), 12.
Cairns, L. (2015). Building inspection failures delay sign-offs. Retrieved from https://www.stuff.co.nz/the-press/business/the-rebuild/67451850/building-inspection-failures-delay-sign-offs

Carla, W. (2016). Building code pros and cons: Is the system in need of an overhaul? Retrieved from https://www.constructiondive.com/news/building-code-pros-and-cons-is-the-system-in-need-of-an-overhaul/419457/

Carla Williams. (2016). Building code pros and cons: Is the system in need of an overhaul? Retrieved from https://www.constructiondive.com/news/building-code-pros-and-cons-is-the-system-in-need-of-an-overhaul/419457/

Caulley, D. N. (1983). Document analysis in program evaluation. *Evaluation and Program Planning, 6*(1), 19-29. doi:https://doi.org/10.1016/0149-7189(83)90041-1

CERC. (2011). Final report: Volume 1. Retrieved from https://canterbury.royalcommission.govt.nz/Final-Report---Summary-and-Recommendations

Chandel, S., Sharma, A., & Marwaha, B. M. (2016). Review of energy efficiency initiatives and regulations for residential buildings in India. *Renewable and Sustainable Energy Reviews, 54*, 1443-1458.

Charytonowicz, J., & Falcão, C. (2018). *Advances in Human Factors, Sustainable Urban Planning and Infrastructure: Proceedings of the AHFE 2018 International Conference on Human Factors, Sustainable Urban Planning and Infrastructure, July 21-25, 2018, Loews Sapphire Falls Resort at Universal Studios, Orlando, Florida, USA* (Vol. 788): Springer.

Ching, F. D., & Winkel, S. R. (2018). *Building Codes Illustrated: A Guide to Understanding the 2018 International Building Code*: John Wiley & Sons.

Chitraker Navesh. (2015). Over 2,50,000 buildings damaged in Nepal quake. Retrieved from https://www.thehindu.com/news/international/over-250000-buildings-damaged-in-nepal-quake/article7161808.ece

Chmutina, K., & Bosher, L. (2015). Disaster risk reduction or disaster risk production: The role of building regulations in mainstreaming DRR. *International journal of disaster risk reduction, 13*, 10-19.

Chong, O. (2013a). APEC Building codes, regulations and standards. In: APEC Sub-committee on standards and conformance APEC committee on trade and ....

Chong, O. (2013b). APEC Building codes, regulations and standards. *APEC Sub-committee on standards and conformance APEC committee on trade and.*

Chong, O., & Ricciarini, S. (2015). Green building code infrastructure guide. Retrieved from file:///C:/Users/user/Downloads/Final%20Green%20Code%20Infrastructure%20Guide_May2015e.pdf

https://webcache.googleusercontent.com/search?q=cache:3hjlV1cBc00J:https://skills.org.nz/assets/Government/docs/Nat-Diploma-in-Building-Control-Surveying-Medium-Large-Buildings-Lev-6.pdf+&cd=12&hl=en&ct=clnk&gl=nz

CIE. (2002). *Benefits of building regulation reform*. Australia: Australian Building Codes Board.

Clark, C., & Catts, R. (2007). Information skills survey: its application to a medical course. *Evidence Based Library and Information Practice, 2*(3), 3-26.

Clift, M. (1996). Building quality assessment (BQA) for offices. *Structural Survey*.

Coburn, A., & Spence, R. (2003). *Earthquake protection*: John Wiley & Sons.

Coglianese, C., Nash, J., & Olmstead, T. (2003). Performance-based regulation: Prospects and limitations in health, safety, and environmental protection. *Admin. L. Rev., 55*, 705.

Cohen, L., Manion, L., & Morrison, K. (2013). *Research methods in education*: routledge.

Colosi, L. (2006). Designing an effective questionnaire. *Research brief available online at: http://parenting. cit. cornell. edu/documents/Designing an Effective Questionnaire. pdf.*

Conners, J. B. (1995). *Coastal Exposure & Community Protection: Hurricane Andrew's Legacy*: Diane Publishing Company.

Consumer Build. (2004). We explain why there are leaky homes in New Zealand and identify the main causes of leaking. Retrieved from https://web.archive.org/web/20111218085655/http://www.consumerbuild.org.nz/publish/leaky/leaky-background.php

Cooke, P. W. (1979). *Research and Innovation in the Building Regulatory Process: Proceedings of the Third Annual NBS/NCSBCS Joint Conference, Held in Annapolis, Maryland on September 12, 1978, in Conjunction with the Eleventh Annual Meeting of the National Conference of States on Building Codes and Standards, Inc.(NCSBCS)* (Vol. 552): US Department of Commerce, National Bureau of Standards.

Cooper, H. M. (1998). *Synthesizing research: A guide for literature reviews* (Vol. 2): Sage.

Cooper, P. W. (2009). Weathertightness – Estimating the Cost. Retrieved from https://www.interest.co.nz/sites/default/files/PWC-leaky%20homes%20report.pdf

Corbin, J., & Strauss, A. (2008). Strategies for qualitative data analysis. *Basics of Qualitative Research. Techniques and procedures for developing grounded theory, 3.*

Corbin, J., & Strauss, A. (2014). *Basics of qualitative research: Techniques and procedures for developing grounded theory*: Sage publications.

Craig DeFriez. (2014). How code complexity Harms Our Profession: Part 2. Retrieved from https://www.structuremag.org/wp-content/uploads/2014/08/D-StrucForum-Defriez-Sept141.pdf

Cresswell, J. (2014). *Research design: Qualitative, Quantitative, and Mixed Methods Approaches.* (Fourth ed.): Sage publications Thousand Oaks.

Creswell, J. W., & Clark, V. L. P. (2017). *Designing and conducting mixed methods research*: Sage publications.

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*: Sage publications.

Creswell, J. W., & Poth, C. N. (2016). *Qualitative inquiry and research design: Choosing among five approaches*: Sage publications.

Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). Thousand Oaks: Sage publications.

Croley, S. P. (2009). *Regulation and public interests: The possibility of good regulatory government*: Princeton University Press.

Crotty, M. (1998). *The foundations of social research: Meaning and perspective in the research process*: Sage Publications Ins.

CSSC. (1995). Northridge earthquake, Turning loss to gain. Retrieved from https://ssc.ca.gov/forms_pubs/ssc95-01.html

D'Ayala, D. (2003). The Kocaeli, Turkey Earthquake of 17 August 1999: a field report by EEFIT. Retrieved from https://www.istructe.org/IStructE/media/Public/Resources/report-eefit-kocaeli-turkey-20190814.PDF

Dall'Oglio, A. M., Rossiello, B., Coletti, M. F., Caselli, M. C., Ravà, L., Di Ciommo, V., . . . Pasqualetti, P. (2010). Developmental evaluation at age 4: validity of an Italian parental questionnaire. *Journal of paediatrics and child health, 46*(7-8), 419-426.

David Kelly. (2012). Streamlining building regulation: Proposed changes to the New Zealand Building Code. Retrieved from https://treasury.govt.nz/sites/default/files/2012-03/ris-dbh-sbr-mar12.pdf

David Norman, Matthew Curtis, & Ian Page. (2014). A cost-benefit analysis of improved working at heights regulation. Retrieved from https://www.sitesafe.org.nz/globalassets/about-us/safety-liaison-group/waikato/3-cost-benefit-analysis-of-the-working-at-heights-programme.pdf

David Wheeldon. (2014). Building Code of Australia (BCA) updates extended to three-year cycle. Retrieved from https://www.architectureanddesign.com.au/news/building-code-of-australia-bca-updates-extended-to

Dawes, J. (2008). Do data characteristics change according to the number of scale points used? An experiment using 5-point, 7-point and 10-point scales. *International journal of market research, 50*(1), 61-104.

DBH. (2010). Using the Product Assurance Framework to Support Building Code Compliance: A Guide for Manufacturers and Suppliers of Building Products Retrieved from https://www.bifnz.co.nz/documents/pafg.pdf

Deakin, H., & Wakefield, K. (2014). Skype interviewing: Reflections of two PhD researchers. *Qualitative research, 14*(5), 603-616. doi:https://doi.org/10.1177/1468794113488126

Deepak Pant. (2015). Nepal Earthquake Clearinghouse. Retrieved from http://learningfromearthquakes.org/2015-04-25-nepal/

Deighton-Smith, R., & Jacobs, S. H. (1997). *Regulatory impact analysis: best practices in OECD countries*: OECD.

Demotte, R. D., & Paciaroni, R. F. (2014). There are several ways contracts can help you avoid delays in design approval. Retrieved from http://www.klgates.com/files/Publication/4f633fe3-f9a3-4498-9d10-a68e94d59d1a/Presentation/PublicationAttachment/271ae15a-827b-4c04-a437-ab0a9ee8e94f/Construction_Today.pdf

Denton S, & M, A. (2017). Performance-based requirements: Meaning, limitations and ways forward. *White paper for the Structural Engineering Institute*.

Dermott McMeel, & Kevin Sweet. (2016). *Roadmap for supporting innovation in the New Zealand Construction Sector*. Retrieved from New Zealaand: chrome-extension://oemmndcbldboiebfnladdacbdfmadadm/https://www.branz.co.nz/cms_show_download.php?id=c8262629abcbcec9b62161bca93a9296afe431d6

Deroukakis, E. (2000). Performance-based codes: impact on international trade. *Occasional Paper* Retrieved from http://ircc.info/Doc/Impact_on_International_Trade.pdf
Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). *Internet, phone, mail, and mixed-mode surveys: the tailored design method*: John Wiley & Sons.
Dixit, A., & Esteban, L. (2009). Safer Building Codes and Construction: A Strategy for Enforcement, Implementation and Dissemination. *The Second Session of Global Platform for Disaster Risk Reduction.* Retrieved from https://nanopdf.com/download/safer-building-codes-and-construction-a-strategy_pdf
Dixit Amod, & Esteban Leon. (2009). Safer Building Codes and Construction: A Strategy for Enforcement, Implementation and Dissemination. *The Second Session of Global Platform for Disaster Risk Reduction.* Retrieved from https://nanopdf.com/download/safer-building-codes-and-construction-a-strategy_pdf
Dizhur, D., Ingham, J., Moon, L., Griffith, M., Schultz, A., Senaldi, I., . . . Centeno, J. (2011). Performance of masonry buildings and churches in the 22 February 2011 Christchurch earthquake.
Don Hunn, Ian Bond, & David Kernohan. (2002). Report of the overview group on the weathertightness of building to the building industry authority. Retrieved from https://www.stepupgroup.co.nz/wp-content/uploads/2011/09/32682.pdf
Douglas, J. (2006). *Building adaptation*: Routledge.
Downs, A. (1991). The advisory commission on regulatory barriers to affordable housing: Its behavior and accomplishments.
Duncan, J. (2005). Performance-based building: lessons from implementation in New Zealand. *Building Research & Information, 33*(2), 120-127.
Duncan John. (2000). *Meeting society and user needs for a built environment.* Paper presented at the Asia Pacific Structural Engineering & Construction Conference (APSEC) 2000: Construction industry - the challenges ahead, Kualar Lumpur, September 2000, Malaysia. https://www.branz.co.nz/cms_show_download.php?id=071de8d3fcf5451537e893a1a9bd1a99030e9d9f
Duncan, J. R. (2002a). *Innovation in the building sector: Trends and new technologies*: BRANZ.
Duncan, J. R. (2002b). *Innovation in the building sector: Trends and new technologies*. Paper presented at the IPENZ Convention, Wellington, New Zealand. https://www.branz.co.nz/cms_show_download.php?id=9d1d0353028ec424f922ba67696376e6e0254421
Dyer, P. (2019). Rottenomics: The story of New Zealand's leaky buildings disaster. *Auckland, New Zealand: David Bateman Limited.*
Easterby-Smith, M., Thorpe, R., Jackson, P. R., & Jaspersen, L. J. (2018). *Management and business research*: Sage.
Egbelakin, T., Yakubu, I., & Bowden, J. (2018). Enhancing seismic regulatory compliance practices for non-structural elements in New Zealand. *Bulletin of the New Zealand Society for Earthquake Engineering, 51*(1), 47-54.

Egbelakin, T. K. (2013). *Incentives and Motivators for Enhancing Earthquake Risk Mitigation Decision.* University of Auckland,
Eisenberg, D., Done, R., & Ishida, L. (2002). *Breaking down the barriers: Challenges and solutions to code approval of green building*: Development Center for Appropriate Technology Tucson, AZ.
Eisenhardt, M. K.(1989). Agency theory: An assessment and review. *Academy of management Review, 14*(1), 57.
Elffers, H., Verboon, P., & Huisman, W. (2006). *Managing and maintaining compliance*: Eleven International Pub.
Elliott, J., Nissen, E., England, P., Jackson, J. A., Lamb, S., Li, Z., . . . Parsons, B. (2012). Slip in the 2010–2011 Canterbury earthquakes, New Zealand. *Journal of Geophysical Research: Solid Earth, 117*(B3).
Elliott, M. (1981). The impact of growth control regulations on housing prices in California. *Real Estate Economics, 9*(2), 115-133.
Eric Baczuk. (2016). The benefits of turning housing construction into housing production. Retrieved from https://medium.com/sidewalk-talk/the-benefits-of-turning-housing-construction-into-housing-production-2513fffea933
Evan, B. (2018). The Importance of Subject Matter Experts. Retrieved from https://thetrainingassociates.com/blog/subject-matter-experts-importance/
Evans, M., & Martinez, J. (2016). Involving Stakeholders in Adoption & Implementation of Building Energy Codes. Retrieved from https://www.buildup.eu/en/events/involving-stakeholders-adoption-implementation-building-energy-codes
FEMA. (2019). Building code fact sheet. Retrieved from https://www.fema.gov/media-library-data/20130726-1903-25045-1885/building_codes_toolkit_fact_sheet.pdf
Fenton-O'Creevy, M. (1998). Employee involvement and the middle manager: evidence from a survey of organizations. *Journal of Organizational Behavior: The International Journal of Industrial, Occupational and Organizational Psychology and Behavior, 19*(1), 67-84.
Ferrari, R. (2015). Writing narrative style literature reviews. *Medical Writing, 24*(4), 230-235. doi:https://doi.org/10.1179/2047480615Z.000000000329
Finstad, K. (2010). Response interpolation and scale sensitivity: Evidence against 5-point scales. *Journal of Usability Studies, 5*(3), 104-110.
Flick, U. (2013). *The SAGE handbook of qualitative data analysis*: Sage.
Foliente, G. (2002). *QUALITATIVE VERSUS QUANTITATIVE ASPECTS OF PERFORMANCE-BASED REGULATIONS.* Paper presented at the 4th International Conference on Performance-Based Codes and Fire Safety Design Methods, Melbourne, Australia
Foliente, G. C. (2000). Developments in performance-based building codes and standards. *Forest Products Journal, 50*(7/8), 12.
Freiku, S. (2003). Kumasi Developments Getting Worse, Chaotic. Ghanaian Chronicle, 31 January 2003. In.
Frey, B. B. (2018). *The SAGE encyclopedia of educational research, measurement, and evaluation*: Sage Publications.
Friedman, M. (1937). The use of ranks to avoid the assumption of normality implicit in the analysis of variance. *Journal of the american statistical association, 32*(200), 675-701.

Gabrielle, P. (2018). Less bureaucracy, more flexibility. Retrieved from https://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=12136233
Gann, D. M., Wang, Y., & Hawkins, R. (1998). Do regulations encourage innovation?-the case of energy efficiency in housing. *Building Research & Information, 26*(5), 280-296.
GBPN. (2014). Designing and implementing best practice building codes: Insights from policy makers. Retrieved from https://www.gbpn.org/sites/default/files/05_Design%20and%20implementation%20of%20best%20practice%20building%20codes.pdf
Georgina Campbell. (2019). Staff shortages slowing down Wellington building consents. Retrieved from https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=12292557
Georgiou, J., Love, P., & Smith, J. (1999). A comparison of defects in houses constructed by owners and registered builders in the Australian State of Victoria. *Structural Survey*.
Gharaati, M., & Davidson, C. (2008). *Who knows best? An overview of reconstruction after the earthquake in Bam, Iran.* Paper presented at the Proceedings of the 4th International i-Rec Conference.
Gilles Maria. (2018). Less bureaucracy, more safety: overhauling the system that led to Grenfell. Retrieved from https://www.building.co.uk/communities/less-bureaucracy-more-safety-overhauling-the-system-that-led-to-grenfell/5091778.article
Glaeser, E. L., & Gyourko, J. (2003). The impact of building restrictions on housing affordability. *Economic Policy Review, 9*(2).
Gledhill, K., Ristau, J., Reyners, M., Fry, B., & Holden, C. (2010). The Darfield (Canterbury) earthquake of September 2010. *Bulletin of the New Zealand Society for Earthquake Engineering, 43*(4), 215-221.
Glenn, J. M., & Wolfe, J. M. (1996). The Growth of the Informal Sector and Regularisation of Spontaneous Development: Lessons from the Caribbean for planning law reform. *Third World Planning Review, 18*(1), 59.
Glenn, M. (2017). Hurricane Andrew: The benchmark. Retrieved from https://www.insblogs.com/uncategorized/hurricane-andrew-benchmark/7761
Glenn McGillivray. (2017). Hurricane Andrew: The benchmark. Retrieved from https://www.insblogs.com/uncategorized/hurricane-andrew-benchmark/7761
Gliem, J. A., & Gliem, R. R. (2003). *Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for Likert-type scales.*
GNS. (2010). 2010 Darfield (Canterbury) Earthquake. Retrieved from https://www.gns.cri.nz/Home/Our-Science/Natural-Hazards-and-Risks/Recent-Events/Canterbury-quake/Darfield-Earthquake
Goda, K., Kiyota, T., Pokhrel, R. M., Chiaro, G., Katagiri, T., Sharma, K., & Wilkinson, S. (2015). The 2015 Gorkha Nepal earthquake: insights from earthquake damage survey. *Frontiers in Built Environment, 1*, 8. Retrieved from https://www.frontiersin.org/articles/10.3389/fbuil.2015.00008/full

Goel R. K. (2003). Performance of buildings during the January 26, 2001 Bhuj earthquake.
Goodman, R. (1997). The Strengths and Difficulties Questionnaire: a research note. *Journal of child psychology and psychiatry, 38*(5), 581-586. doi:https://doi.org/10.1111/j.1469-7610.1997.tb01545.x
Gouldthorpe, J. L., & Israel, G. D. (2014). The savvy survey# 6c: Constructing closed-ended items for a questionnaire. In: The Savvy Survey series, University of Florida, US. Available at: https ….
Gray, D. E. (2014). *Doing research in the real world*: Sage.
Green, B. N., Johnson, C. D., & Adams, A. (2006). Writing narrative literature reviews for peer-reviewed journals: secrets of the trade. *Journal of chiropractic medicine, 5*(3), 101-117. doi:https://doi.org/10.1016/S0899-3467(07)60142-6
Greene, J. C., Caracelli, V. J., & Graham, W. F. (1989). Toward a conceptual framework for mixed-method evaluation designs. *Educational evaluation and policy analysis, 11*(3), 255-274.
Greener, I. (2011). *Designing social research: A guide for the bewildered*: Sage Publications.
Greenwood, D., Lockley, S., Malsane, S., & Matthews, J. (2010). *Automated compliance checking using building information models.* Paper presented at the The Construction, Building and Real Estate Research Conference of the Royal Institution of Chartered Surveyors, Paris 2nd-3rd September.
Greenwood, J. (2007). An Examination of the Performance Based Building Code on the Design of a Commercial Building. *Construction Economics and Building, 7*(1), 37-44.
Grix, J. (2018). *The foundations of research* (3rd ed.): Macmillan International Higher Education.
Gross, J. G. (1979). *Impact of Building Regulations on Rehabilition: Status and Technical Needs* (Vol. 998): US Department of Commerce, National Bureau of Standards.
Gülkan, P. (2001). The search for enhanced disaster resistance of the building stock in Turkey: recent legislative measures for effective building code enforcement and mitigation policies. *Consultancy Report for the World Bank and Turkish Treasury, TEFER, Government of Turkey, Ankara.*
Gülkan, P., Balamir, M., Sucuoğlu, H., Ersoy, M., Duygu, B., Bademli, R., & Tankut, G. (1999). Revision of the Turkish Development Law No. 3194 and its Attendant Regulations with the Objective of Establishing a New Building Construction Supervision System Inclusive of Incorporating Technical Disaster Resistance-Enhancing Measures (3 Volumes). *Turkish Ministry of Public Works and Settlement, Istanbul.*
Gupta, I., Sinvhal, A., & Shankar, R. (2006). Himalayan population at earthquake risk. *Disaster Prevention and Management: An International Journal.*
Haberecht, P. W., & Bennett, A. F. (1999). *Experience with durability assessment and performance-based building codes*: BRANZ.
Hammond, M., & Wellington, J. (2012). *Research methods: The key concepts*: Routledge.
Hammond, M., & Wellington, J. (2013). *Research methods: The key concepts*: Routledge.

Hasegawa, T. (2013). Introduction to the Building Standard Law-Building regulation in Japan. 1-212. *Building Center of Japan, Tokyo*.
Hassan, Z. A., Schattner, P., & Mazza, D. (2006). Doing a pilot study: why is it essential? *Malaysian family physician: the official journal of the Academy of Family Physicians of Malaysia, 1*(2-3), 70.
Hay, C. (2007). Does ontology trump epistemology? Notes on the directional dependence of ontology and epistemology in political analysis. *Politics, 27*(2), 115-118. Retrieved from https://journals.sagepub.com/doi/pdf/10.1111/j.1467-9256.2007.00287.x
Hayes, G., Briggs, R., Sladen, A., Fielding, E., Prentice, C., Hudnut, K., . . . Gold, R. (2010). Complex rupture during the 12 January 2010 Haiti earthquake. *Nature Geoscience, 3*(11), 800-805.
HBRI. (2015). Bangladesh National Building Code Retrieved from https://policy.asiapacificenergy.org/sites/default/files/Bangladesh%20National%20Building%20Code%202015%20%28volume%201%20of%203%29.pdf
Healy, M., & Perry, C. (2000a). Comprehensive criteria to judge validity and reliability of qualitative research within the realism paradigm. *Qualitative market research: An international journal*. doi:https://doi.org/10.1108/13522750010333861
Healy, M., & Perry, C. (2000b). Comprehensive criteria to judge validity and reliability of qualitative research within the realism paradigm. *Qualitative market research: An international journal, 3*(3), 118 - 126. doi:https://doi.org/10.1108/13522750010333861
Heidebrecht, A. (2003). Seismic design implications of revisions to the National Building Code of Canada. *Bulletin of the New Zealand Society for Earthquake Engineering, 36*(2), 108-116.
Heijden, J. V. d. (2016). Opportunities and risks of the "new urban governance" in India: To what extent can it help addressing pressing environmental problems? *The Journal of Environment & Development, 25*(3), 251-275.
Heijden, J. v. d., Visscher, H., & Meijer, F. (2007). Problems in enforcing Dutch building regulations. *Structural Survey, 25*(3-4), 319-329.
Heijden Van der, & De Jong Jeroen. (2009). Towards a better understanding of building regulation. *Environment and Planning B: Planning and Design, 36*(6), 1038-1052.
Heli Aramo-Immonen. (2013). Mixed Methods Research Design. Retrieved from https://link.springer.com/chapter/10.1007/978-3-642-35879-1_5
Hinton, P. R., McMurray, I., & Brownlow, C. (2014). *SPSS explained*: Routledge.
Holladay, S. J., & Coombs, W. T. (1993). Communicating visions: An exploration of the role of delivery in the creation of leader charisma. *Management Communication Quarterly, 6*(4), 405-427. doi:https://doi.org/10.1177/0893318993006004003
Hopkins, P., & Unger, M. (2017). What is a'subject-matter expert'? *Journal of Pipeline Engineering, 16*(4).
Hubbard Dennis, & Timothy M. Pastore (1997). *New Zealand Building Regulations Five Years Later* University of Canterbury New Zealand. Retrieved from https://ir.canterbury.ac.nz/bitstream/handle/10092/8488/hubbardpastore_fire_research_97-9.pdf;sequence=1

Hudson, F. S., Sutrisna, M., & Chawynski, G. (2020). A certification framework for managing the risks of non-compliance and non-conformance building products: a Western Australian perspective. *International journal of building pathology and adaptation*.
Huisman, W., Elffers, H., & Verboon, P. (2006). Managing and maintaining compliance. Closing the gap between science and practice.
Hunn, D., Bond, I., & Kernohan, D. (2002). *Report of the overview group on the weathertightness of buildings to the building industry authority*: Building Industry Authority.
Hunter, S., & Waterman, R. W. (1992). Determining an agency's regulatory style: how does the EPA water office enforce the law? *Western Political Quarterly, 45*(2), 403-417.
Ian Page, & Greta Gordon. (2017). What is quality in building? Retrieved from https://www.branz.co.nz/cms_show_download.php?id=3a755303151dbaf4a9fe04e56f5be968f6991633
IBC. (2006). *International building code*. USA: International Code Council, Inc.
IBHS. (2015). Building Code Resources: The Benefits of Statewide Building Codes Retrieved from https://21ro1f2g715d2qfj633cf0mm-wpengine.netdna-ssl.com/wp-content/uploads/2019/01/The-Benefits-of-Statewide-Building-Codes_IBHS.pdf
Ilki, A., & Celep, Z. (2012). Earthquakes, existing buildings and seismic design codes in Turkey. *Arabian Journal for Science and Engineering, 37*(2), 365-380.
Ilozor, B., Okoroh, M., & Egbu, C. (2004). Understanding residential house defects in Australia from the State of Victoria. *Building and Environment, 39*(3), 327-337.
Imrie, R. (2004). The role of the building regulations in achieving housing quality. *Environment and Planning B: Planning and Design, 31*(3), 419-437.
Ingham, J., & Griffith, M. (2010). Performance of unreinforced masonry buildings during the 2010 Darfield (Christchurch, NZ) earthquake. *Australian Journal of Structural Engineering, 11*(3), 207-224.
IRC. (2010a). Canada's National Model Construction Codes Development System. Retrieved from http://ircc.info/Doc/IBCS.pdf
IRC. (2010b). Canada's National Model Construction Codes Development System. Retrieved from http://ircc.info/Doc/IBCS.pdf
Ivankova, N. V. (2014). Implementing quality criteria in designing and conducting a sequential QUAN→ QUAL mixed methods study of student engagement with learning applied research methods online. *Journal of Mixed Methods Research, 8*(1), 25-51.
Jackson, E. (2013). Choosing a methodology: Philosophical underpinning. *Practitioner Research in Higher Education, 7*(1), 49-62.
Jackson, K., & Bazeley, P. (2019). *Qualitative data analysis with NVivo*: SAGE Publications Limited.
Jahan, N., Naveed, S., Zeshan, M., & Tahir, M. A. (2016). How to conduct a systematic review: a narrative literature review. *Cureus, 8*(11).
Jain, S. K. (2002). Codes, licensing, and education. *Earthquake Spectra, 18*(1_suppl), 319-339.

James, M. (2016). *The New Zealand Building Code Verification Method VM2–Four Years on–A Practitioner's Perspective.* Paper presented at the Proceedings of the 11 th Conference on Performance-Based Codes and Fire Safety Design Methods, Society of Fire Protection Engineers, Warsaw, Poland.

James, Z., & Mike, H. (2012). *Weathertight buildings: What lessons can be drawn?* Paper presented at the New Zealand Association of Economists New Zealand. https://www.nzae.org.nz/wp-content/uploads/2012/06/Zuccollo_NZAE2012_paper.pdf

James Zuccollo, & Mike Hensen. (2012). *Weathertight buildings: What lessons can be drawn?* Paper presented at the New Zealand Association of Economists New Zealand. https://www.nzae.org.nz/wp-content/uploads/2012/06/Zuccollo_NZAE2012_paper.pdf

Jenny, R. (2019). Deloitte report shows building material costs are low. Retrieved from https://www.scoop.co.nz/stories/BU1905/S00546/deloitte-report-shows-building-material-costs-are-low.htm

Jenny Salesa. (2019). Over 120 standards used for Building Code compliance funded for free download. Retrieved from https://www.beehive.govt.nz/release/over-120-standards-used-building-code-compliance-funded-free-download

Jeong, J., & Lee, G. (2009). *Requirements for automated code checking for fire resistance and egress rule using BIM.* Paper presented at the International Construction Management Conference-Final Program & Abstract Book.

Jerry Velasquez. (2016). Improve Building Code Practices to Reduce Disaster Losses and Improve Resilience. Retrieved from https://www.linkedin.com/pulse/improve-building-code-practices-reduce-disaster-losses-velasquez/

JICA. (2017). Knowledge Co-Creation Program: Disaster Prevention of Buildings Retrieved from https://www.jica.go.jp/uzbekistan/english/activities/c8h0vm0000btnh8x-att/J1704291.pdf

Jishnu, K. S. (2008). *Framework for Building Code Implementation: Experience of Housing Earthquake Safety Initiative - HESI.* Paper presented at the International Symposium 2008 on Earthquake Safe Housing, Tokyo, Japan. https://www.preventionweb.net/files/10591_HESITokyoPapers.pdf

Jishnu Kumar Subedi. (2008). *Framework for Building Code Implementation: Experience of Housing Earthquake Safety Initiative - HESI.* Paper presented at the International Symposium 2008 on Earthquake Safe Housing, Tokyo, Japan. https://www.preventionweb.net/files/10591_HESITokyoPapers.pdf

Johannesson, P., & Perjons, E. (2014). Research paradigms. In *An Introduction to Design Science* (pp. 167-179): Springer.

John Bleasby. (2019). MMAH proposals add red tape, complexity for inspectors: OBOA. Retrieved from https://canada.constructconnect.com/dcn/news/associations/2019/12/mmah-proposals-add-red-tape-complexity-for-inspectors-oboa

John R. Duncan. (2000). *Meeting society and user needs for a built environment* Paper presented at the Asia Pacific Structural Engineering &ConstructionConference, The Mines Resort City, Malaysia.

Johnny, S. (2009). The Coding Manual for Qualitative Researchers Retrieved from https://stevescollection.weebly.com/uploads/1/3/8/6/13866629/saldana_2009_the-coding-manual-for-qualitative-researchers.pdf

Johnson, C. (2011). Creating an enabling environment for reducing disaster risk: Recent experience of regulatory frameworks for land, planning and building in low and middle-income countries. *Background Paper for the Global Assessment Report on Disaster Risk Reduction, 2011*.

Johnson, L. A., Coburn, A., Rahnama, M., Halling, M., Morrow, G., Bendimerad, F., & Piepenbrock, T. (2000). Damage survey approach to estimating insurance losses. *Earthquake Spectra, 16*(S1), 281-293.

Jonathan, H. (2018). Resilience and the National Model Building Codes. Retrieved from http://constructionexec.com/article/resilience-and-the-national-model-building-codes

Jones, S., & Vasvani, V. (2017a). Compliance with the building bye-laws and earthquake safety in urban areas of Bihar: progress, constraints and challenges. *Environmental Hazards, 16*(4), 345-362.

Jones, S., & Vasvani, V. (2017b). Compliance with the building byelaws and earthquake safety in urban areas of Bihar: progress, constraints and challenges. *Environmental Hazards, 16*(4), 345-362.

Jørgensen, K. B., & Jensen, L. E. (2011). Introduction to NVivo 9.0. Retrieved from https://medarbejdere.au.dk/fileadmin/www.medarbejdere.au.dk/it/BSS_Analysevaerktoejer/NVivo/Manual_Nvivo_9.0.pdf

Juntunen, M., & Lehenkari, M. (2019). A narrative literature review process for an academic business research thesis. *Studies in Higher Education*, 1-13. doi:https://doi.org/10.1080/03075079.2019.1630813

Kagan, R. A., & Scholz, J. T. (1980). The “criminology of the corporation” and regulatory enforcement strategies. In *Organisation und recht* (pp. 352-377): Springer.

KaganRobert, & Bardach Eugene. (1982). Going by the Book: The Problem of Regulatory Unreasonableness. *New Brunswick, NJ: Transaction Publishers*.

Kandel, C. R. (2007). A step towards compliance with building codes. Retrieved from http://peer.nset.org.np/nset/html/newsletter/NSET_newsletter_2007_Dec.pdf

Kanga, R. A., & Scholz, J. T. (1984). The'Criminology'of theCorporation and Regulatory Enforcement Strategies. *K. Hawkins andJ. Thomas (eds.), Enforcing Regulation. Boston: Kluwer-Nijhoff. Kagan1984Enforcing RegulationThe Criminology of the Corporation and Regulatory Enforcement Strategies*.

Karen Andrews. (2015). Free online access to National Construction Code. Retrieved from https://www.minister.industry.gov.au/ministers/andrews/media-releases/free-online-access-national-construction-code

Kausel, E. (2010) *Strict building code may explain lower Chile toll/Interviewer: M. Block*.

Kazdin, A. E. (2016). *Methodological issues and strategies in clinical research*: American Psychological Association.

Keith Manch, & Peter Burke. (2011). ACHIEVING COMPLIANCE: A Guide for Compliance Agencies in New Zealand. Retrieved from https://g-reg.govt.nz/wp-content/uploads/2019/04/AchievingComplianceGuide_17July2011.pdf

Kelly, D. (2012). Streamlining building regulation: Proposed changes to the New Zealand Building Code. Retrieved from https://treasury.govt.nz/sites/default/files/2012-03/ris-dbh-sbr-mar12.pdf

Kelly, L. (1995). *ASTD Technical and Skills Training Handbook*: ERIC.

Kenji, O. (2008). Institutional Mechanism of Building Code Implementation in Japan. Retrieved from http://www.uncrd.or.jp/hyogo/hesi/pdf/nepal08/training/okazaki2.pdf

Kenji Okazaki. (2008). Institutional Mechanism of Building Code Implementation in Japan. Retrieved from http://www.uncrd.or.jp/hyogo/hesi/pdf/nepal08/training/okazaki2.pdf

Kenny, C. (2009). *Why do people die in earthquakes? The costs, benefits and institutions of disaster risk reduction in developing countries*: The World Bank.

Khan, R. A., Uneb, G., & Fawwad, M. (2010). *Monetary Effects of Building Regulations–A Case Study of Karachi Building Construction.* Paper presented at the Second International Conference on Construction in Developing Countries (ICCIDC-II). "Advantages and Integrating Construction Education, Research & Practice", Cairo, Egypy. https://www.researchgate.net/publication/288835929_Monetary_Effects_of_Building_Regulations_-_A_Case_Study_of_Karachi_Building_Construction

Khan Raza Ali, Uneb Gazder, & Fawwad Masood. (2010). *Monetary Effects of Building Regulations–A Case Study of Karachi Building Construction.* Paper presented at the Second International Conference on Construction in Developing Countries (ICCIDC-II). "Advantages and Integrating Construction Education, Research & Practice", Cairo, Egypy. https://www.researchgate.net/publication/288835929_Monetary_Effects_of_Building_Regulations_-_A_Case_Study_of_Karachi_Building_Construction

Kitomulo. (2017). Advantages & disadvantages of public opinion as an influence. Retrieved from https://getrevising.co.uk/grids/advantages-and-disadvantages-of-public-opinion-as

Krause, N. (2002). A comprehensive strategy for developing closed-ended survey items for use in studies of older adults. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 57*(5), S263-S274.

Krimgold, F. (2011). Disaster risk reduction and the evolution of physical development regulation. *Environmental Hazards, 10*(1), 53-58.

Kris Hudson, & Jeffrey Sparshott. (2015). Labor Shortage Pinches Home Builders. Retrieved from https://www.wsj.com/articles/labor-shortage-pinches-home-builders-1444688976

Kumar, A. (2017). Problems and prospects of building regulations in Shimla, India–A step towards achieving sustainable development. *International Journal of Sustainable Built Environment, 6*(1), 207-215.

Langstone, F. (2016). Building (Earthquake-prone Buildings) Amendment Act 2016. Retrieved from https://www.feelangstone.co.nz/blog/2018/2/9/a-closer-look-at-building-earthquake-prone-buildings-amendment-act-2016#:~:text=About%20the%20Act,deal%20with%20earthquake%2Dprone%20buildings.
Larmore, S. (2011). Subject Matter Expert: Working Toward Ensuring The Value In A Project Organization.
Lauren, U. (2018). The Climate is Changing. So Why Aren't State Building Codes? Retrieved from https://www.nrdc.org/experts/lauren-urbanek/climate-changing-why-arent-state-building-codes
Lauren Urbanek (2018). The Climate is Changing. So Why Aren't State Building Codes? Retrieved from https://www.nrdc.org/experts/lauren-urbanek/climate-changing-why-arent-state-building-codes
Lavin, R. P., Dreyfus, M., Slepski, L., & Kasper, C. E. (2007). *Said Another Way Subject Matter Experts: Facts or Fiction?* Paper presented at the Nursing forum.
Lavrakas, P. J. (2008). *Encyclopedia of survey research methods*: Sage Publications.
Lawrance, G., Hopkins, D., Cheong, D., & Stannard, M. (2014). *Review of the Building Code Structural Provisions.* Paper presented at the New Zealand Society of Earthquake Engineering (NZSEE) Conference.
Lawrence Neuman, W. (2014). Social research methods: Qualitative and quantitative approaches. In: Pearson.
Lee, E. (2008). Socio-political contexts, identity formation, and regulatory compliance. *Administration & Society, 40*(7), 741-769.
Lee Neil, Bennett J.M., Jones M.S., Marston N.J., & Kear G. (2008). *A durability assessment tool for the new zealand building code*. Paper presented at the 11th International Conference on Durability of Building Materials and Components (11 DBMC), Istanbul, Turkey. https://www.branz.co.nz/cms_show_download.php?id=b93e02d42dff255511b9028ac63e199cea76b8f8
Leedy, P. D., & Ormrod, J. E. (2005). *Practical research* (Ninth ed.). USA: Pearson Custom.
Leung, S.-O. (2011). A comparison of psychometric properties and normality in 4-, 5-, 6-, and 11-point Likert scales. *Journal of Social Service Research, 37*(4), 412-421.
Levi-Faur, D. (2011). The regulatory state and regulatory capitalism: an institutional perspective. *Chapters*.
Lewis-Beck, M., Bryman, A. E., & Liao, T. F. (2003). *The Sage encyclopedia of social science research methods*: Sage Publications.
Likert Rensis. (1932). A technique for the measurement of attitude. *Archieves of Psychology, 22*, 5 - 55. Retrieved from https://legacy.voteview.com/pdf/Likert_1932.pdf
Lindell, M. K. (2010). Built-in resilience. *Nature Geoscience, 3*(11), 739-740.
Listokin, D., & Hattis, D. B. (2005). Building codes and housing. *Cityscape*, 21-67.
Liu, F., Meyer, A. S., & Hogan, J. F. (2010). *Mainstreaming building energy efficiency codes in developing countries: global experiences and lessons from early adopters*: The World Bank.

Lois Cairns. (2015). Building inspection failures delay sign-offs. Retrieved from https://www.stuff.co.nz/the-press/business/the-rebuild/67451850/building-inspection-failures-delay-sign-offs

Lovegrove, K. (1991). *The Model Building Act: For Consideration by the States and Territories: Legislative Aims and Options*: Australian Uniform Building Regulations Co-ordinating Council.

Lundin, J. (2006). *Fire risk control in a performance-based regulatory system–challenges and shortcomings.* Paper presented at the Proceedings of the 6th International Conference on Performance-Based Codes and Fire Safety Design Methods, Society of Fire Protection Engineers (SFPE), Bethesda, MD, US.

Lundin, J. A. (2005). *Safety in case of fire: The effect of changing regulations.* (Doctor of Philosophy in Engineering). Lund University, Sweden Retrieved from https://lup.lub.lu.se/search/ws/files/4793881/26604.pdf

Mack, L. (2010). The philosophical underpinnings of educational research. In: Polyglossia.

Maclntosh, R., & O'Gorman, K. (2015). Mapping Reserach Methods. *Research Methods for Business and Management*, 1-74.

Maki, N., & Hayashi, H. (2000). *Building codes and tradeoffs for earthquake risk reduction: Disaster management for housing.* Paper presented at the Proceedings of 12th World Conference on Earthquake Engineering (CD-ROM).

Mannakkara, S., & Wilkinson, S. (2013). Post-disaster legislation for building back better. *Constr. Law J, 29*(8), 495-506.

Margaret Levi. (1988). Of Rule and Revenue. Retrieved from https://scholar.princeton.edu/sites/default/files/tpavone/files/margaret_levi-of_rule_and_revenue_summary.pdf

Marshall, M. N. (1996). The key informant technique. *Family practice, 13*(1), 92-97. doi:10.1093/fampra/13.1.92Corpus ID: 2887103

Martin, C. (2005). Response to" Building Codes and Housing" by David Listokin and David B. Hattis. *Cityscape*, 253-259.

Martin sexton, & barrett, P. (2005). Performance -based building and innovation: balancing client client and industry needs. *Building Research & Information, 2*(33), 142 - 148. doi:10.1080/0961321042000323789

Matthew, C. (2009). Building Act review – opportunity to get rid of some red tape. Retrieved from http://www.chapmantripp.com/publications/building-act-review-%E2%80%93-opportunity-to-get-rid-of-some-red-tape

Maugard, A., Duffaure-Gallois, I., & Rubinstein, M. (1998). Le bâtiment demain et après-demain. In: Editions du CSTB.

Maurice, W. (2012). *A new future for New Zealand's building industry*. Retrieved from New Zealand: https://webcache.googleusercontent.com/search?q=cache:9uYE_cgNSTIJ:https://www.anzsog.edu.au/documents/360-new-future-for-new-zealand-s-building-industry-a-2012-134-1/file+&cd=1&hl=en&ct=clnk&gl=nz

Maurice Williamson. (2012). *A new future for New Zealand's building industry.* Retrieved from New Zealand: https://webcache.googleusercontent.com/search?q=cache:9uYE_cgNSTIJ:ht tps://www.anzsog.edu.au/documents/360-new-future-for-new-zealand-s-building-industry-a-2012-134-1/file+&cd=1&hl=en&ct=clnk&gl=nz

Maxwell, J. (2013). Qualitative research design: An interactive approach . Chapter 6: Validity: How might you be wrong.

Maxwell, J. A. (2013). Applied social research methods series: Vol. 41. *Qualitative research design: An interactive approach, 3*.

May Peter. (2003). Performance-based regulation and regulatory regimes: the saga of leaky buildings. *Law & Policy, 25*(4), 381-401. doi:https://doi.org/10.1111/j.0265-8240.2003.00155.x

May, P. J. (2003). Performance-based regulation and regulatory regimes: the saga of leaky buildings. *Law & Policy, 25*(4), 381-401.

May, P. J. (2004). Compliance motivations: Affirmative and negative bases. *Law & Society Review, 38*(1), 41-68.

May, P. J. (2005). Regulatory implementation: Examining barriers from regulatory processes. *Cityscape*, 209-232.

MBIE. (2004). Building Act 2004. Retrieved from https://www.building.govt.nz/building-code-compliance/how-the-building-code-works/building-act-2004/

MBIE. (2005). Buildings that must be accessible for people with disabilities. Retrieved from https://www.building.govt.nz/building-code-compliance/d-access/d1-access-routes/buildings-that-must-be-accessible-for-people-with-disabilities/

MBIE. (2006). Regulation 7 – Performing building control functions. Retrieved from https://www.building.govt.nz/building-officials/bca-accreditation/detailed-regulatory-guidance/7-perform-building-control-functions/

MBIE. (2008). Issuing an infringement notice. Retrieved from https://www.building.govt.nz/building-officials/guides-for-building-officials/building-infringement-scheme-guidelines/issuing-an-infringement-notice/

MBIE. (2013). External moisture – a guide to using the risk matrix: A companion guide to Acceptable Solution E2/AS1. Retrieved from https://www.building.govt.nz/assets/Uploads/building-code-compliance/e-moisture/e2-external-moisture/e2-riskmatrix.pdf

MBIE. (2014a). Acceptable Solutions and Verification Methods. Retrieved from https://www.building.govt.nz/building-code-compliance/how-the-building-code-works/different-ways-to-comply/acceptable-solutions-and-verification-methods/#jumpto-acceptable-solutions-__0028as__0029

MBIE. (2014b). Building Code and handbooks. Retrieved from https://www.building.govt.nz/building-code-compliance/building-code-and-handbooks/

MBIE. (2014c). New Zealand Building Code Handbook. Retrieved from https://www.building.govt.nz/assets/Uploads/building-code-compliance/handbooks/building-code-handbook/building-code-handbook-3rd-edition-amendment-13.pdf

MBIE. (2015). Summary of the building performance regulatory system assessment. Retrieved from

https://www.mbie.govt.nz/assets/f5b5aeec12/summary-of-building-regulatory-system-assessment.pdf
MBIE. (2016a). Acceptable Solutions and Verification Methods. Retrieved from https://www.building.govt.nz/building-code-compliance/how-the-building-code-works/different-ways-to-comply/acceptable-solutions-and-verification-methods/
MBIE. (2016b). Alternative solutions for compliance with the Building Code. Retrieved from https://www.building.govt.nz/building-code-compliance/how-the-building-code-works/different-ways-to-comply/alternative-solutions/
MBIE. (2016c). *Building Code and handbooks*. Retrieved from New Zealand: https://www.building.govt.nz/building-code-compliance/building-code-and-handbooks/
MBIE. (2016d). Building regulatory system. Retrieved from https://www.mbie.govt.nz/cross-government-functions/regulatory-stewardship/regulatory-systems/building-regulatory-system/
MBIE. (2016e). Code compliance certificates. Retrieved from https://www.building.govt.nz/building-officials/guides-for-building-officials/code-compliance-certificates-cccs/
MBIE. (2016f). Compliance schedules. Retrieved from https://www.building.govt.nz/projects-and-consents/sign-off-and-maintenance/completing-your-project/compliance-schedules/
MBIE. (2016g). Making an amendment to your building's compliance schedule. Retrieved from https://www.building.govt.nz/managing-buildings/managing-your-bwof/amendments-to-compliance-schedules/
MBIE. (2016h). Practice Advisory 16: Quality assurance in design and construction. Retrieved from https://www.building.govt.nz/building-code-compliance/b-stability/b1-structure/practice-advisory-16/
MBIE. (2016i). Proposals for regulations under the building (Earthquake-prone Buildings) Amendment Act 2016. Retrieved from https://www.mbie.govt.nz/assets/cf97192b40/discussion-document-proposals-for-regulations-under-the-building-earthquake-prone-buildings-amendment-act-2016.pdf
MBIE. (2016j). Record of amendments – Acceptable Solutions, Verification Methods and handbooks (1993–2019). Retrieved from https://www.building.govt.nz/assets/Uploads/building-code-compliance/how-the-building-code-works/amendment-history-compliance-documents.pdf
MBIE. (2016k). Showing your products comply with the Building Code. Retrieved from https://www.building.govt.nz/building-code-compliance/product-assurance-and-multiproof/product-assurance/products-and-building-code-compliance/
MBIE. (2017a). About Building Performance. Retrieved from https://www.building.govt.nz/about-building-performance/
MBIE. (2017b). About Building Performance: We want everyone to have safe, healthy, durable homes and buildings, supporting MBIE's goal to grow New Zealand for all. Retrieved from https://www.building.govt.nz/about-building-performance/

MBIE. (2017c). Change of use, alterations and extension of life. Retrieved from https://www.building.govt.nz/managing-buildings/change-of-use-and-alterations/

MBIE. (2017d). Managing earthquake-prone buildings. Retrieved from https://www.building.govt.nz/managing-buildings/managing-earthquake-prone-buildings/

MBIE. (2017e). Regulation 5 – Requirements for policies, procedures and systems. Retrieved from https://www.building.govt.nz/building-officials/bca-accreditation/detailed-regulatory-guidance/5-requirements-policies-procedures-systems/

MBIE. (2017f). Regulation 13 – Ensuring technical leadership. Retrieved from https://www.building.govt.nz/building-officials/bca-accreditation/detailed-regulatory-guidance/13-technical-leadership/

MBIE. (2017g). Regulatory Charter: Building regulatory system. Retrieved from https://www.mbie.govt.nz/dmsdocument/3083-regulatory-charter-building-pdf

MBIE. (2017h). *Responses to the Canterbury Earthquakes Royal Commission recommendations* Retrieved from New Zealand: https://www.mbie.govt.nz/assets/27c53c4193/responses-cerc-recommendations.pdf

MBIE. (2018a). Building and maintaining New Zealand's homes and buildings. Retrieved from https://www.mbie.govt.nz/building-and-energy/building/building-and-maintaining-new-zealands-homes-and-buildings/

MBIE. (2018b). MBIE to consult twice yearly on changes to the Building Code System. Retrieved from https://www.building.govt.nz/about-building-performance/news-and-updates/all-news-and-updates/bc-update-237/

MBIE. (2018c). Smarter Compliance Pathways. *Summary of Findings.* Retrieved from https://webcache.googleusercontent.com/search?q=cache:M5HKjS3QaCcJ:https://www.mbie.govt.nz/dmsdocument/4330-smarter-compliance-pathways-summary-of-findings+&cd=1&hl=en&ct=clnk&gl=nz

MBIE. (2019a). Building regulatory system. Retrieved from https://www.mbie.govt.nz/cross-government-functions/regulatory-stewardship/regulatory-systems/building-regulatory-system/

MBIE. (2019b). *Building system legislative reform*. Retrieved from New Zealand: chrome-extension://oemmndcbldboiebfnladdacbdfmadadm/https://www.mbie.govt.nz/dmsdocument/5009-building-system-legislative-reform-discussion-paper

MBIE. (2019c). Building System Legislative: Reform Programme. Retrieved from https://www.mbie.govt.nz/dmsdocument/6590-building-system-legislative-reform-programme-summary-of-submissions

MBIE. (2019d). Have your say on major changes to building laws. Retrieved from https://www.building.govt.nz/about-building-performance/news-and-updates/codewords/codewords-issue-90/have-your-say-on-major-changes-to-building-laws/

MBIE. (2019e). Latest improvements to the Building Code have been published. Retrieved from https://www.building.govt.nz/about-building-

performance/news-and-updates/all-news-and-updates/latest-improvements-to-the-building-code-have-been-published/
MBIE. (2019f). MBIE funds over 120 building standards for free download. Retrieved from https://www.building.govt.nz/about-building-performance/news-and-updates/all-news-and-updates/mbie-funds-over-120-building-standards-for-free-download/
MBIE. (2019g). Public consultation: overhaul for building legislation. Retrieved from https://www.building.govt.nz/about-building-performance/news-and-updates/codewords/codewords-issue-88/public-consultation-overhaul-for-building-legislation/
MBIE. (2019h). Updates to the Building Code will make it easier to comply. *Building Controls Update 249.* Retrieved from https://www.building.govt.nz/about-building-performance/news-and-updates/all-news-and-updates/updates-to-the-building-code-will-make-it-easier-to-comply/
MBIE. (2019i). Updates to the Building Code will make it easier to comply. Retrieved from https://www.building.govt.nz/about-building-performance/news-and-updates/all-news-and-updates/updates-to-the-building-code-will-make-it-easier-to-comply/
MBIE. (2019j). Updates to the Building Code will make it easier to comply. Retrieved from https://www.building.govt.nz/about-building-performance/news-and-updates/all-news-and-updates/updates-to-the-building-code-will-make-it-easier-to-comply/
MBIE. (2020a). Building Code update consultation June 2020. Retrieved from https://www.mbie.govt.nz/have-your-say/building-code-update-consultation-june-2020/
MBIE. (2020b). Building Code update June 2020. Retrieved from https://www.building.govt.nz/about-building-performance/news-and-updates/codewords/codewords-issue-94/building-code-update-june-2020/
MBIE. (2020c). Continuing to improve the Building Code. Retrieved from https://www.building.govt.nz/about-building-performance/news-and-updates/codewords/codewords-issue-94/continuing-to-improve-the-building-code/
MBIE. (2020d). Continuing to improve the Building Code. Retrieved from https://www.building.govt.nz/about-building-performance/news-and-updates/codewords/codewords-issue-94/continuing-to-improve-the-building-code/
McGuirk, P. M., & O'Neill, P. (2016). Using questionnaires in qualitative human geography.
McLean, J. S. (2017). *Navigational Complexity Within Building Codes.* (Doctor of Philosophy). The University of Vermont USA. Retrieved from https://scholarworks.uvm.edu/cgi/viewcontent.cgi?article=1811&context=graddis
McLeod, S. (2018). Questionnaire. Retrieved from https://www.simplypsychology.org/questionnaires.html
McLeod, S. (2019). What a p-value tells you about statistical significance. Retrieved from https://www.simplypsychology.org/p-value.html

McNiff, K. (2016). What is Qualitative Research? *The Nvivo Blog: QSR International, on November.* Retrieved from https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/resources/blog/what-is-qualitative-research

Meacham, B. (1998). The evolution of performance based codes and fire safety design methods, Report NIST GCR 98–761. *National Institute of Standards and Technology, Gaithersburg, MD.*

Meacham, B. (2010a). Accommodating innovation in building regulation: lessons and challenges. *Building Research & Information, 38*(6), 686-698. doi:https://doi.org/10.1080/09613218.2010.505380

Meacham, B. (2010b). Performance-based building regulatory systems principles and experiences. *A report of the inter-jurisdictional Regulatory Collaboration Committee,(IRCC). Australian Building Codes Board (ABCB), Australia, February.* Retrieved from https://ircc.info/Doc/A1163909.pdf

Meacham, B., Bowen, R., Traw, J., & Moore, A. (2005). Performance-based building regulation: current situation and future needs. *Building Research & Information, 33*(2), 91-106.

Meacham, B., Bowen, R., Traw, J., & Moore, A. (2005). Performance-based building regulation: current situation and future needs. *Building Research & Informatio, 33*(2), 91-106.

Meacham, B., Tubbs, B., Bergeron, D., & Szigeti, F. (2003). Performance system model-a framework for describing the totality of building performance. *CIB REPORT*, 361-372.

Meacham, B. J. (1997). Concepts of a performance-based building regulatory system for the United States. *Fire Safety Science, 5*, 701-712.

Meacham, B. J. (2009). *Performance-Based Building Regulatory Systems*: A Report of the Inter-jurisdictional Regulatory Collaboration Committee.

Meacham, B. J. (2010a). Accommodating innovation in building regulation: lessons and challenges. *Building Research & Information, 38*(6), 686-698.

Meacham, B. J. (2010b). Risk-informed performance-based approach to building regulation. *Journal of Risk Research, 13*(7), 877-893.

Meacham, B. J. (2016). Sustainability and resiliency objectives in performance building regulations. *Building Research & Information, 44*(5-6), 474-489. doi:https://doi.org/10.1080/09613218.2016.1142330

Meacham Brian. (1999). *Fire safety analysis and design in a performance based regulatory system.* Paper presented at the Proceedings of Global Building Model in the Next Millennium Conference.

Meacham Brian. (2008). Performance Requirements and Acceptance Criteria for Safety in Case of Fire. *IRCC Workshop on Fire Performance and Criteria* Retrieved from https://www.ircc.info/new%20page/Workshops/Documents/Austria2007_reportIRCC_workshop.pdf

Meacham Brian. (2010). Performance-based building regulatory systems principles and experiences. *A report of the inter-jurisdictional Regulatory Collaboration Committee,(IRCC). Australian Building Codes Board (ABCB), Australia, February.* Retrieved from https://ircc.info/Doc/A1163909.pdf

Meacham Brian J. (2008). *Performance Requirements and Acceptance Criteria for Safety in Case of Fire*. Retrieved from Vienna, Austria: chrome-extension://oemmndcbldboiebfnladdacbdfmadadm/http://ircc.azurewebsites.net/new%20page/Workshops/Documents/Austria2007_reportIRCC_workshop.pdf
Meeks, C., & Brannigan, V. (1996). *Performance based codes: economic efficiency and distributional equity.* Paper presented at the International Inter am Conference, 7th Proceedings March.
Menum C., & Mistry R. (2001). The January 2001 Gujarat Earthquake. *The John A. Blume Earthquake Engineering Center summer*, 27.
Meres, R., Sigmon, J., DeWein, M., Garrett, K., & Brown, J. (2012). Successful strategies for improving compliance with building energy codes. *Proceedings of the ACEEE 2012 Summer Study on Energy Efficiency in Buildings, 4*, 275-288.
Merriam, S. B. (1998). *Qualitative Research and Case Study Applications in Education. Revised and Expanded from" Case Study Research in Education."*: ERIC.
Michael Finn, & Alastair Soane. (2007). Annual Report 2006: The role and operation of the Building Regulations Advisory Committee (BRAC). Retrieved from https://www.bipsolutions.com/docstore/pdf/17743.PDF
Michael Mills. (2010a). Regulatory Impact Assessment Retrieved from https://treasury.govt.nz/sites/default/files/2017-01/ris-dbh-bar2-jul10.pdf
Michael Mills. (2010b). Regulatory Impact Assessment. *Building Act review: Proposals and options for reform Agency Disclosure Statement.* Retrieved from https://treasury.govt.nz/sites/default/files/2017-01/ris-dbh-bar2-jul10.pdf
Mills, M. (2010). Regulatory Impact Assessment. *Building Act review: Proposals and options for reform Agency Disclosure Statement.* Retrieved from https://treasury.govt.nz/sites/default/files/2017-01/ris-dbh-bar2-jul10.pdf
Ministry of Business, I. a. E. M. (2016). *Alternative solutions for compliance with the Building Code*. Retrieved from https://www.building.govt.nz/building-code-compliance/how-the-building-code-works/different-ways-to-comply/alternative-solutions/
Mistry, R., Dong, W., & Shah, H. C. (2001). *Interdisciplinary observations on the January 2001 Bhuj, Gujarat earthquake*: World Seismic Safety Initiative.
Mohamed, I. F., Edwards, D. J., Mateo-Garcia, M., Costin, G., & Thwala, W. D. D. (2019). An investigation into the construction industry's view on fire prevention in high-rise buildings post Grenfell. *International journal of building pathology and adaptation.*
Mohammed, A. (1997). Problems in translating NGO successes into government settlement policy: illustrations from Trinidad and Tobago and Jamaica. *Environment and Urbanization, 9*(2), 233-246.
Molloy, D. (2014). Builders guide to timber. Retrieved from https://web.archive.org/web/20130219045528/http://www.branz.co.nz/cms_show_download.php?id=cf6625f585bcb1f1d918316b7326ec58ea591e53
Moon, K., & Blackman, D. (2017). A guide to ontology, epistemology, and philosophical perspectives for interdisciplinary researchers. In.

Moullier, T. (2014). Improving building code implementation and compliance for more resilient buildings in developing countries: Considerations for policy makers. *Global Facility for Disaster Risk Reduction, Washington DC.*
Moullier, T., & Krimgold, F. (2015). Building regulation for resilience: managing risks for safer cities. *The World Bank, Washington DC* https://www. *gfdrr. org/sites/default/files/publication/BRR% 20report. pdf.*
Moullier Thomas, & Keiko Sakoda. (2018). Converting Disaster Experience into a Safer Built Environment:The Case of Japan. Japan. Retrieved from http://pubdocs.worldbank.org/en/162361520295760910/jp-publication-drmhubtokyo-convertingdisaster-experience-into-a-safer-built-environment.pdf
Mumford, P. J. (2010). Enhancing Performance-Based Regulation: Lessons from New Zealand's Building Control System.
Murphy, C. (2003). *The New Zealand building code–A failed experiment.* Paper presented at the Proceedings of the 37th Australian & New Zealand Architectural Science Association Conference.
Murphy, C. (2011). Building control changes: the on-going battle against the leaking building. *Architectural Science Review, 54*(2), 157-163. doi:https://doi.org/10.1080/00038628.2011.582392
Murphy, K. (2017). Procedural justice and its role in promoting voluntary compliance. *Regulatory theory: Foundations and applications*, 43-58.
NCBCS. (2018a). Benefits and challenges of a timely code adoption cycle. Retrieved from https://cdn.ymaws.com/www.nibs.org/resource/resmgr/ncgbcs/NCBCS_TimelyCodeAdoption.pdf
NCBCS. (2018b). Benefits and Challenges of aTimely Code Adoption Cycle. Retrieved from https://cdn.ymaws.com/www.nibs.org/resource/resmgr/ncgbcs/NCBCS_TimelyCodeAdoption.pdf
NCC. (2015a). The National Construction Code Retrieved from https://www.builderassist.com.au/wp-content/uploads/2016/02/NCC2015-BCA-Volume-One.pdf
NCC. (2015b). *National Construction Code*. Retrieved from Australia: https://ncc.abcb.gov.au/ncc-online/About
NCC. (2016). BCA History. Retrieved from https://ncc.abcb.gov.au/ncc-online/About/BCA-History
Neuman, W. L. (2014). *Social Research Methods: Qualitative and Quantitative Approaches: Pearson New International Edition*: Pearson Education Limited.
Nguyen, N. B. (2006). The Development of Construction Codes and Standards in Vietnam. *In ACECC workshop on Harmonization of Design codes in the Asian Region.* Retrieved from http://www.jsce.or.jp/committee/acecc/code/11_ws2006-nbnguyen-r.pdf.
Nick, S. (2016). Proposals for Regulations under the Building (Earthquake-prone Buildings) Amendment Act 2016. Retrieved from https://www.mbie.govt.nz/assets/cf97192b40/discussion-document-proposals-for-regulations-under-the-building-earthquake-prone-buildings-amendment-act-2016.pdf

Nick Smith. (2014). Proposals to change the occupational regulation of engineers in New Zealand. Retrieved from https://www.nzia.co.nz/media/1037/2014_4-september_engineers-proposal-document.pdf

Nicole, B. (2017). Epistemology Retrieved from https://www.nicole-brown.co.uk/epistemology/

Nigel, I. (2011). Early building legislation. Retrieved from https://www.buildmagazine.org.nz/index.php/articles/show/early-building-legislation

Nigel Isaacs. (2011). Early building legislation. Retrieved from https://www.buildmagazine.org.nz/index.php/articles/show/early-building-legislation

Nigel Isaacs. (2018). Why our building regulation just doesn't cut it. Retrieved from https://www.newsroom.co.nz/ideasroom/2018/06/06/112722/why-our-building-regulation-just-doesnt-cut-it

Nigel, L. (2019). What's the average survey response rate? Retrieved from https://surveyanyplace.com/average-survey-response-rate/#:~:text=What%20is%20the%20average%20survey,33%25.

Nikki, B. (2014). A Code to build by. Retrieved from https://www.buildmagazine.org.nz/index.php/articles/show/a-code-to-build-by

Nikki Buckett. (2014). A Code to build by. Retrieved from https://www.buildmagazine.org.nz/index.php/articles/show/a-code-to-build-by

Nilson, D. C., & Olson, R. S. (1981). *Policies and Implementation: Enforcing the Seismic Provisions of Building Regulations.* Paper presented at the Annual Meeting of the Western Political Science Association, Denver, Colorado.

Norwegian Building Authority. (2016). *Notification of regulations on technical requirements for building works.* Retrieved from Norway: https://webcache.googleusercontent.com/search?q=cache:giLpLPCYLBwJ:https://ec.europa.eu/growth/tools-databases/tris/de/index.cfm/search/%3Ftrisaction%3Dsearch.detail%26year%3D2016%26num%3D9041%26iLang%3DEN+&cd=1&hl=en&ct=clnk&gl=nz

Nuth, M., & Duncan, A. (2019). *Medium-density housing technical issues.* Retrieved from New Zealand: https://www.branz.co.nz/cms_show_download.php?id=425a499ff232921b55e0b8d062383e173f28575a

Nwadike, A., & Wilkinson, S. (2020a). Building Code Amendment Process: A Case Study of New Zealand. Retrieved from https://www.researchgate.net/profile/Amarachukwu_Nwadike/publication/340828395_Building_Code_Amendment_Process_A_Case_Study_of_New_Zealand/links/5e9ff48092851c2f52ba684c/Building-Code-Amendment-Process-A-Case-Study-of-New-Zealand.pdf

Nwadike, A., & Wilkinson, S. (2020b). Challenges facing building code compliance in New Zealand. *International Journal of Construction Management.* doi:10.1080/15623599.2020.1801336

Nwadike, A., & Wilkinson, S. (2020c). Challenges facing building code compliance in New Zealand. *International Journal of Construction Management*, 1-11.

Nwadike, A., & Wilkinson, S. (2020d). *Impacts of innovation in performance-based building code*. Paper presented at the NZSEE 2020 Annual Technical Conference, Wellington, New Zealand. https://repo.nzsee.org.nz/bitstream/handle/nzsee/1700/Nwadike0039.pdf?sequence=1&isAllowed=y

Nwadike, A., & Wilkinson, S. (2020e). Impacts of innovation in performance-based building code. Retrieved from https://www.researchgate.net/publication/342466639_Impacts_of_innovation_in_performance-based_building_code

Nwadike, A., Wilkinson, S., & Clifton, C. (2019a, June, 2019). *Comparative Insight on Building Code Paradigm Shift Practice and Updates: International Perspectives.* Paper presented at the The 4th International Conference on Civil, Structural and Transportation Engineering (ICCSTE'19), Ottawa, Canada

Nwadike, A., Wilkinson, S., & Clifton, C. (2019b). *Comparative Insight on Building Code Paradigm Shift Practice and Updates: International Perspectives.* Paper presented at the 4th International Conference on Civil, Structural and Transportation Engineering (ICCSTE'19), Ottawa, Canada

Nwadike, A., Wilkinson, S., & Clifton, C. (2019c). *Improving disaster resilience through effective building code compliance*. Paper presented at the 9th International i-Rec Conference 2019, University of Florida, Gainesville, United States. https://www.preventionweb.net/events/view/61094?id=61094

Nwadike, A., Wilkinson, S., & Clifton, C. (2019d). Improving disaster resilience through effective building code compliance. *9th International i-Rec Conference 2019.* Retrieved from http://www.grif.umontreal.ca/i-Rec2019/Improving%20disaster%20resilience%20through%20effective%20building%20code%20compliance.pdf

Nwadike, A. N., & Wilkinson, S. (2021). Why amending building codes? An investigation of the benefits of regular building code amendment in New Zealand. *International journal of building pathology and adaptation*.

Nyachhyon, B. (2017). Rebuilding Nepal for next earthquake. *Revista ALCONPAT, 7*(1), 104-118.

O'Cathain, A., Murphy, E., & Nicholl, J. (2007). Why, and how, mixed methods research is undertaken in health services research in England: a mixed methods study. *BMC health services research, 7*(1), 85.

O'leary, Z. (2017). *The essential guide to doing your research project*: Sage.

O'Mathúna, D. P. (2000). Evidence-based practice and reviews of therapeutic touch. *Journal of Nursing Scholarship, 32*(3), 279-285.

Offei-Nketiah, J. K., Kwofie, T. E., & Duah, D. Y. A. (2019). *Regulatory Distress: Architects' Perspective on Enforcement of Building Regulations in Ghana.* Paper presented at the Construction Industry Development Board Postgraduate Research Conference.

Oladinrin, T., & Ho, C. (2015). Barriers to effective implementation of ethical codes in construction organizations: An empirical investigation. *International Journal of Construction Management, 15*(2), 117-125.

Oliver, P. (2010). *Understanding the research process*. London: Sage.
Olshansky, R. (1996). *Could seismic zonation have helped Los Angeles? Reflections on the uses of seismic zonation in reducing earthquake risks.* Paper presented at the Proceedings of the fifth international conference on seismic zonation (Nice, October 17-19, 1995).
Olshansky, R. B. (1998). *Promoting the adoption and enforcement of seismic building codes: A guidebook for state earthquake and mitigation managers*: FEMA.
Onwuegbuzie, A. J., & Collins, K. M. (2007). A typology of mixed methods sampling designs in social science research. *Qualitative Report, 12*(2), 281-316.
Ormston, R., Spencer, L., Barnard, M., & Snape, D. (2014). The foundations of qualitative research. *Qualitative research practice: A guide for social science students and researchers, 2*, 52-55. Retrieved from https://books.google.co.nz/books?hl=en&lr=&id=EQSIAwAAQBAJ&oi=fnd&pg=PA1&dq=Snape,+D.,+%26+Spencer,+L.+(2003).+The+foundations+of+qualitative+research+In+J.+Richie+%26+J.+Lewis+(Eds.),+Qualitative+Research+Practice+(pp.+1-23).+Los+Angeles:+Sage.++++(12)+(PDF)+Demystifying+Ontology+and+Epistemology+in+Research+Methods.+Available+from:+&ots=l-PVnoRx2J&sig=TYTM91nWPyd61coLNNVr7BFP6cU&redir_esc=y#v=onepage&q&f=false
Östlund, U., Kidd, L., Wengström, Y., & Rowa-Dewar, N. (2011). Combining qualitative and quantitative research within mixed method research designs: a methodological review. *International journal of nursing studies, 48*(3), 369-383.
Owen, G. T. (2014). Qualitative methods in higher education policy analysis: Using interviews and document analysis. *The qualitative report, 19*(26), 1.
Owusu-Mensah, K. (2003). Community Participation in Town and Country Planning: A Delayed but Welcoming. GNA. In.
Oxman, A. D. (1994). Systematic reviews: checklists for review articles. *Bmj, 309*(6955), 648-651.
Pace, D. K., & Sheehan, J. (2002). *Subject matter expert (SME)/peer use in M&S V&V.* Paper presented at the Foundations for the V&V in the 21st Century workshop (Foundations 2002), John Hopkins University.
Pam Williams. (2020). Frequently asked questions Retrieved from https://buildstrongamerica.com/issue/frequently-asked-questions/
Parajuli, Y. K., Bothara, J. K., Dixit, A. M., Pradhan, J. P., & Sharpe, R. (2000). *Nepal Building Code-Need, Development Philosophy and Means of Implementation.* Paper presented at the 12th World Conference on Earthquake Engineering, Auckland, New Zealand, January.
Pat, H. (2013). Prescriptive Codes: A Cure or a Curse? Retrieved from https://www.energy.gov/sites/prod/files/2013/12/f5/issue6_prescriptive_codes.pdf
Paul Everall. (2003). *PERFORMANCE BASED BUILDING LEGISLATION: THE UK EXPERIENCE.* Retrieved from UK: chrome-extension://oemmndcbldboiebfnladdacbdfmadadm/http://ircc.azurewebsites.net/new%20page/Workshops/Documents/USA2003_6-03_PaulEverall_workshops.pdf

Pearson, C., & Delatte, N. (2005). Ronan point apartment tower collapse and its effect on building codes. *Journal of Performance of Constructed Facilities, 19*(2), 172-177.
Pence, E. (2006). Code complexity and information overload: Where will it end? Retrieved from https://www.structuremag.org/wp-content/uploads/2014/09/C-Editorial-Oct061.pdf
Petak, W. J., & Elahi, S. (2000). *The Northridge earthquake, USA and its economic and social impacts.* Paper presented at the Euro-conference on global change and catastrophe risk management, earthquake risks in Europe, IIASA.
Pilzer, D., & Jasuja, M. (2005). Performance based building regulations. *PeBBu Domain, 7*.
Porter, M. (1990). The competitive advantage of nations/Michael E. Porter. *NY: The Free press. A Division of Macmillan Inc, 855*.
Preston, V. (2009). Questionnaire Survey. *International Encyclopedia of Human Geography*, 46-52. doi:10.1016/B978-008044910-4.00504-6
Punch, K. F. (2013). *Introduction to social research: Quantitative and qualitative approaches*: sage.
Quarantelli, E. (2003). Urban vulnerability to disasters in developing countries: managing risks. *Building Safer Cities, 211*.
R.E. Humpreys. (1985). *Innovation and building controls*. Paper presented at the Institution of Professional Engineers New Zealand Wellington, New Zealand. chrome-extension://oemmndcbldboiebfnladdacbdfmadadm/https://www.branz.co.nz/cms_show_download.php?id=c549e906ec756a801e666147f46cd477c77a04cd
Rahman, M. (2010). *Complexity in building design.* Paper presented at the Proceedings of the 3rd International Holcim Forum for Sustainable Construction,"Re-Inventing Construction.
Ram, K. C. (2017). A Step towards compliance with Building codes. Retrieved from https://www.dpnet.org.np/uploads/files/A%20step%20towards%20compliance%20with%20building%20code%202019-04-08%2007-09-00.pdf
Raman, S. (1997). *Sizing up the policy information system for energy efficient construction.* Paper presented at the Proceedings of the 1997 ECEEE Summer Study.
Rapley, T. (2007). *The Sage Qualitative Research Kit*: SAGE.
Rapley, T. (2008). *Doing conversation, discourse and document analysis*: Sage.
Real Estate Authority. (2020). Learning about leaky buildings. Retrieved from https://www.settled.govt.nz/buying-a-home/researching-the-property/learning-about-leaky-buildings/?gclid=Cj0KCQiA7qP9BRCLARIsABDaZzj00BoXuvwvwBn3h9HQbR2_eKNBO0wgDfvf4orAbW50TbG1SFuqYdkaAnPFEALw_wcB
Regulations, N. C. o. B. (1976). *Programme of Work for the NKB*. Retrieved from Stockholm:
Rehman, A. A., & Alharthi, K. (2016). An introduction to research paradigms. *International Journal of Educational Investigations, 3*(8), 51-59.
Ricciarini Sylvana. (2009). Building codes development, implementation and enforcement. Retrieved from

https://www.preventionweb.net/files/globalplatform/entry_presentation~7SylvanaRicciarini.pdf
Richards, T. (2002). An intellectual history of NUD* IST and NVivo. *International journal of social research methodology, 5*(3), 199-214. doi:doi.org/10.1080/13645570210146267
RNZ. (2018). Building inspectors in short supply across NZ. Retrieved from https://www.rnz.co.nz/national/programmes/morningreport/audio/2018648705/building-inspectors-in-short-supply-across-nz
Rohrmann, B. (1998). The risk notion: epistemological and empirical considerations. *Integrative risk assessment*, 39-46.
Rumrill Jr, P. D., & Fitzgerald, S. M. (2001). Using narrative literature reviews to build a scientific knowledge base. *Work, 16*(2), 165-170.
Russell, C. L. (2005). An overview of the integrative research review. *Progress in transplantation, 15*(1), 8-13. doi:https://doi.org/10.1177/152692480501500102
Russell, H. R. (2002). *Research methods in anthropology: qualitative and quantitative approaches*: Altamira 4.
Sachdev, S. B., & Verma, H. V. (2004). Relative importance of service quality dimensions: A multisectoral study. *Journal of services research, 4*(1).
Samasoni, J. C. (2017). *Evaluating the Feasibility of Implementing a Risk-based Inspection Scheme by Building Consent Authorities in New Zealand.* Auckland University of Technology,
Santos, J. L. G. d., Erdmann, A. L., Meirelles, B. H. S., Lanzoni, G. M. d. M., Cunha, V. P. d., & Ross, R. (2017). Integrating quantitative and qualitative data in mixed methods research. *Texto & Contexto-Enfermagem, 26*(3).
Saul McLeod. (2018). Questionnaire: Definition, Examples, Design and Types. Retrieved from https://www.simplypsychology.org/questionnaires.html
Saunders, N., Beever, P., Wade, C., Fleischmann, C., Feeney, M., Scott, D., & Thorby, P. (2012). *A new framework for performance-based fire engineering design in New Zealand.* Paper presented at the 9th International Conference on Performance-Based Codes and Fire Safety Design Methods, Society of Fire Protection Engineers.
SBCCI. (1992). *Natural Disaster Loss Reduction Committee, National Committee on Property Insurance*. Retrieved from Chicago:
Scawthorn, C. (2011). Disaster Casualties–Accounting for Economic Impacts and Diurnal Variation. In *Human Casualties in Earthquakes* (pp. 51-63): Springer.
Scholz, J. T. (1994). Managing regulatory enforcement in the United States. *Handbook of regulation and administrative law*, 423-463.
Schoonenboom, J., & Johnson, R. B. (2017). How to construct a mixed methods research design. *KZfSS Kölner Zeitschrift für Soziologie und Sozialpsychologie, 69*(2), 107-131.
Scotland, J. (2012). Exploring the philosophical underpinnings of research: Relating ontology and epistemology to the methodology and methods of the scientific, interpretive, and critical research paradigms. *English language teaching, 5*(9), 9-16. Retrieved from https://files.eric.ed.gov/fulltext/EJ1080001.pdf

Scott, G. (2010). Are We Really Better Off With Building Codes? Retrieved from https://www.greenbuildingadvisor.com/article/are-we-really-better-off-with-building-codes

Scott Jason. (2013). Christchurch rebuild to cost $34b. Retrieved from https://www.smh.com.au/world/christchurch-rebuild-to-cost-34b-20130428-2imy9.html

Scott Williams. (2016). Performance-Based Design: Benefits and Pitfalls. Retrieved from https://sourceable.net/performance-based-design-benefits-and-pitfalls/

Searer, G. R. (2006). Poorly worded, ill-conceived, and unnecessary code provisions. *The Structural Design of Tall and Special Buildings, 15*(5), 533-546.

Sedam, S. (2015). Consequences of Complexity in the Building Process. Retrieved from https://www.probuilder.com/consequences-complexity-building-process

Sedlenieks, K. (2004). Corruption in the process of issuing building permits. Retrieved from http://pdc.ceu.hu/archive/00002134/01/kor_buvatl_en[1].pdf

Sedlenieks Klavs. (2004). Corruption in the process of issuing building permits. Retrieved from http://pdc.ceu.hu/archive/00002134/01/kor_buvatl_en[1].pdf

Sexton, M., & Barrett, P. (2005). Performance-based building and innovation: balancing client and industry needs. *Building Research & Information, 33*(2), 142-148.

Shanks, G., & Bekmamedova, N. (2018). *Case study research in information systems* (2nd ed.): Elsevier.

Sharma, B. (2016). A focus on reliability in developmental research through Cronbach's Alpha among medical, dental and paramedical professionals. *Asian Pacific Journal of Health Sciences, 3*(4), 271-278.

Shih, S.-Y., Sher, W., & Giggins, H. (2013). *Assessment of the Building Code of Australia to Inform the Development of BIM-enabled Code-checking Systems.* Paper presented at the Proceedings of CIB World Building Congress.

Shoichi Ando. (2008, 28-29 November 2008). *Experience of Damages in Recent Earthquakes.* Paper presented at the Records and outcomes of International Symposium 2008 on Earthquake Safe Housing Japan.

Sikes, P. (2004). Methodology, procedures and ethical concerns. *Doing educational research*, 15-33.

Sileyew, K. J. (2019). Research Design and Methodology. In *Text Mining-Analysis, Programming and Application*: IntechOpen.

Simon Maude. (2017). Auckland Council apologises to home builder for inspection delays. Retrieved from https://www.stuff.co.nz/business/property/90154084/auckland-council-apologises-to-home-builder-for-inspection-delays

Smallman, E. R. (2019). Lack of building inspectors increases wait times as building boom hits Hamilton. Retrieved from https://www.stuff.co.nz/national/110139014/lack-of-building-inspectors-increases-wait-times-as-building-boom-hits-hamilton

Smith, J. (1999). Turks Blame Inadequate Building Codes. Retrieved from https://www.washingtonpost.com/wp-srv/inatl/daily/aug99/buildings21.htm

Smith, M. B. (1971). A psychologist's perspective on public opinion theory. *Public Opinion Quarterly, 35*(1), 36-43.

Smulowitz, S. (2017). Document Analysis. *The International Encyclopedia of Communication Research Methods*, 1-8. doi:https://doi.org/10.1002/9781118901731.iecrm0071

Snow, J., & Mann, M. (2013). Qualtrics survey software: handbook for research professionals. *Qualtrics Labs, Inc*.

Somiah, M. K., Ayarkwa, J., & Agyekum, K. (2015). Assessing House-Owners' Level of Awareness on The National Building Regulations, LI 1630, in The Sekondi-Takoradi Metropolis. *African Journal of Applied Research (AJAR), 1*(1).

Southland District Council. (2018). *Building Control Activity Management Plan* Retrieved from New Zealand: https://www.southlanddc.govt.nz/assets/LTP2018/AMP/29-AMP-Building-Control-2018-2028-DRAFT-FEB-18.pdf

Sparrow, M. K. (2011). *The regulatory craft: controlling risks, solving problems, and managing compliance*: Brookings Institution Press.

Spence, R. (2004). Risk and regulation: can improved government action reduce the impacts of natural disasters? *Building Research & Information, 32*(5), 391-402.

Spence, W. P., & Kultermann, E. (2016). *Construction materials, methods and techniques*: Cengage Learning.

Spinardi, G., & Law, A. (2019). Beyond the stable door: Hackitt and the future of fire safety regulation in the UK. *Fire Safety Journal, 109*, 102856.

Stefan Debois. (2019). 10 Advantages and Disadvantages of Questionnaires. Retrieved from https://surveyanyplace.com/questionnaire-pros-and-cons/

Subedi, J., & Mishima, N. (2008). Handbook on Building Code Implementation: Learning from Experience of Lalitpur Sub-Metropolitan City. *Nepal, LSMC (Lalitpur Sub-Metropolitan City), Lalitpur and UNCRD (United Nations Centre for Regional Development), Hyogo*.

Sudhir Jain, William Lettis, Murty C.V.R, & Jean-Pierre Bardet. (2002). Bhuj, India Earthquake: Reconnaissance report. Retrieved from https://scholar.googleusercontent.com/scholar?q=cache:K7KgFOpY3tsJ:scholar.google.com/+Spectra,+E.+(2002).+2001+Bhuj,+India+Earthquake+Reconnaissance+Report.+EERI+Publication,+no.+2002-01.&hl=en&as_sdt=0,5

Suresh V. (2002). Promoting safer building construction. Retrieved from https://www.humanitarianlibrary.org/sites/default/files/2014/02/ADPC_PromotingSaferBuildingConstruction.pdf

Susan Farrel. (2016). Open-Ended vs. Closed-Ended Questions in User Research. Retrieved from https://www.nngroup.com/articles/open-ended-questions/

Takahiko, H. (2003). Environmentally sustainable buildings: challenges and policies *Organisation for Economic Co-operation and Development. OECD Paris*. Retrieved from http://www.oecd.org/japan/35896769.pdf

Tan, X., Hammad, A., & Fazio, P. (2010). Automated code compliance checking for building envelope design. *Journal of Computing in Civil Engineering, 24*(2), 203-211.

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International journal of medical education, 2*, 53.

Terpstra, T. (2009). *Flood Preparedness–Thoughts, Feelings and Intentions of The Dutch Public. Twente, University of Twente.* PhD thesis, 98,

Theckethil, R. (2006). Building codes: A regulatory mechanism for reducing the vulnerability of urban areas. *Journal of Security Education, 1*(4), 95-106.

Thiruppugazh, V. (2008). Urban vulnerability reduction: regulations and beyond. In *The Indian Economy Sixty Years After Independence* (pp. 200-212): Springer.

Thompson, G. N. (1947). The problem of building code improvement. *Law and Contemporary Problems, 12*(1), 95-110.

Tongco, M. D. C. (2007). Purposive sampling as a tool for informant selection. *Ethnobotany Research and applications, 5*, 147-158.

Torraco, R. J. (2005). Writing integrative literature reviews: Guidelines and examples. *Human resource development review, 4*(3), 356-367. doi:https://doi.org/10.1177/1534484305278283

Torraco, R. J. (2016). Writing integrative literature reviews: Using the past and present to explore the future. *Human Resource Development Review, 15*(4), 404-428.

UKEssays. (2018). Relationship Between Ontology Epistemology And Methodology Philosophy Essay. Retrieved from https://www.ukessays.com/essays/philosophy/relationship-between-ontology-epistemology-and-methodology-philosophy-essay.php

Umar, T., & Egbu, C. (2018). Perceptions on safety climate: a case study in the Omani construction industry. *Proceedings of the Institution of Civil Engineers-Management, Procurement and Law, 171*(6), 251-263. doi:doi.org/10.1680/jmapl.18.00001

UNDP. (2008). Supporting capacity development: the UNDP approach. Retrieved from https://www.undp.org/content/dam/aplaws/publication/en/publications/capacity-development/support-capacity-development-the-undp-approach/CDG_Brochure_2009.pdf

UNECE. (2015). Outcomes of the Survey on Building Standards and Building Regulations in the UNECE Region Retrieved from https://www.unece.org/fileadmin/DAM/hlm/documents/Publications/Building_standards_survey_outcomes.pdf

UNISDR. (2015a). *Sendai Framework for Disaster Risk Reduction 2015-2030.* Retrieved from Geneva:

UNISDR. (2015b). Sendai Framework for Disaster Risk Reduction 2015-2030. . Retrieved from https://www.ifrc.org/docs/IDRL/Sendai_Framework_for_Disaster_Risk_Reduction_2015-2030.pdf

USAID. (2016). Building code implementation program in Municipalities of Nepal. Retrieved from https://www.usaid.gov/nepal/documents/building-code-implementation-program-municipalities-nepal-bcipn-0

Valentin, V., & Bogus, S. M. (2015). Assessing the link between public opinion and social sustainability in building and infrastructure projects. *Journal of Green Building, 10*(3), 177-190.
Van der Heijden, J., & De Jong, J. (2009). Towards a better understanding of building regulation. *Environment and Planning B: Planning and Design, 36*(6), 1038-1052.
Vaughan, E., & Turner, J. (2013). The value and impact of building codes. *Environmental and Energy Study Institute White Paper.*
Visscher, H., & Meijer, F. (2007). *Dynamics of building regulations in Europe.* Paper presented at the International Conference on Sustainable Urban Areas, ENHR.
Volha, R., & Meredydd, E. (2016). Overview of Stakeholders Participation in Adoption & Implementation of Building Energy Codes. Retrieved from https://cleanenergysolutions.org/sites/default/files/documents/codesstakeholders_webinar-nov30-v5.pdf
Volha Roshchanka, & Meredydd Evans. (2016). Overview of Stakeholders Participation in Adoption & Implementation of Building Energy Codes. Retrieved from https://cleanenergysolutions.org/sites/default/files/documents/codesstakeholders_webinar-nov30-v5.pdf
Wang, L.-H., Hong, C.-F., & Hsu, C.-L. (2006). *Closed-ended questionnaire data analysis.* Paper presented at the International Conference on Knowledge-Based and Intelligent Information and Engineering Systems.
Wasley, K. (2014). *Pre-disaster Recovery Planning: Lessons From Japan.* University of Otago,
Watt, S., Simpson, C., McKillop, C., & Nunn, V. (2002). Electronic course surveys: does automating feedback and reporting give better results? *Assessment & Evaluation in Higher Education, 27*(4), 325-337.
Wayne Thompson. (2005). Building code change sought to avoid ghetto risk. Retrieved from https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=10354668
Weinstein, L. (2008). Mumbai's development mafias: globalization, organized crime and land development. *International Journal of Urban and Regional Research, 32*(1), 22-39.
Wesley, J. J. (2010). *Qualitative document analysis in political science.* Paper presented at the T2PP Workshop.
Whanganui Chronicle. (2017). Council building bureaucracy 'crap' - couple. Retrieved from https://www.nzherald.co.nz/wanganui-chronicle/news/article.cfm?c_id=1503426&objectid=11844247
Whanganui District Council. (2010). What is an alternative solution? Retrieved from https://www.whanganui.govt.nz/files/assets/public/guides-and-information/brochure003-alternativesolutions.pdf
Whittemore, R., & Knafl, K. (2005). The integrative review: updated methodology. *Journal of advanced nursing, 52*(5), 546-553. doi:https://doi.org/10.1111/j.1365-2648.2005.03621.x

Wieczorek, C. (2018). *GETTING TO KNOW INTERNATIONAL BUILDING CODES AND STANDARDS.* Retrieved from https://www.fmglobal.com/insights-and-impacts/2018/wild-wild-west.

Wilkinson Bryce, Crampton Eric, Jason Krupp, & Lianne Dalziel. (2018). *Recipe for disaster: Building policy on shaky ground.* Retrieved from New Zealand: https://www.eqrecoverylearning.org/assets/downloads/recipe-for-disaster-building-policy-on-shaky-ground.pdf

Wilkinson, D. (2002). *The researcher's toolkit: The complete guide to practitioner research*: Routledge.

Wilkinson, S. J., & Remøy, H. (2018). *Building Urban Resilience Through Change of Use*. UK: John Wiley & Sons.

Williams, C. (2016). Building code pros and cons: Is the system in need of an overhaul? Retrieved from https://www.constructiondive.com/news/building-code-pros-and-cons-is-the-system-in-need-of-an-overhaul/419457/

Williams, T., Eden, C., Ackermann, F., & Tait, A. (1995). The effects of design changes and delays on project costs. *Journal of the Operational Research Society, 46*(7), 809-818.

Williamson, M. (2010). Cost-effective quality: Next generation building control in New Zealand. *Building Act Review discussion document.* Retrieved from https://ndhadeliver.natlib.govt.nz/delivery/DeliveryManagerServlet?dps_pid=IE2245768

Wilson, E. (2017). *School-based research: A guide for education students* (3rd ed.). London: Sage.

Windapo, A. O., & Cattell, K. (2010). *A study of building contractors' compliance with national building regulations in Cape Town*. Paper presented at the RICS_COBRA, South Africa. file:///C:/Users/user/Downloads/CIB20060_RICS_COBRA_CONFERENCE_2010.pdf

Wing, C. K., Raftery, J., & Walker, A. (1998). The baby and the bathwater: research methods in construction management. *Construction Management & Economics, 16*(1), 99-104.

Wisdom, J., & Creswell, J. W. (2013). Mixed methods: integrating quantitative and qualitative data collection and analysis while studying patient-centered medical home models. *Rockville: Agency for Healthcare Research and Quality.*

Wright, J. G. (1983). *Building control by legislation: the UK experience*: Wiley.

Wuetherick, B. (2010). Basics of qualitative research: Techniques and procedures for developing grounded theory. *Canadian Journal of University Continuing Education, 36*(2).

Yates, A. (2002a, September 2 -3). *The nexus between regulation enforcement and catastrophic engineering failures.* Paper presented at the Current Issues in Regulation: Enforcement and Compliance, Melbourne.

Yates, A. (2002b). The nexus between regulation enforcement and catastrophic engineering failures. *Current Issues in Regulation: Enforcement and Compliance.*

Yin, R. K. (2006). Mixed methods research: Are the methods genuinely integrated or merely parallel. *Research in the Schools, 13*(1), 41-47.

Yin, R. K. (2018). *Case study research and applications: Design and Methods* (Sixth Edition ed.). United Kingdom: SAGE Publications, Inc.
York, D., Bastian, H., Relf, G., & Amann, J. (2017). Transforming Energy Efficiency Markets: Lessons Learned and Next Steps. In: Washington, DC: American Council for an Energy-Efficient Economy. https ….
Zaidi Mohd Azian. (2010). A prospective study on building quality: enforcement of control in the Australian housing industry. Retrieved from https://www.cmnzl.co.nz/assets/sm/5712/61/1345MohdAzianZaidi.pdf

Appendices

Appendix 1: Questionnaire survey

A QUESTIONNAIRE TO ASSESS IMPACTS OF BUILDING CODE AMENDMENTS AND COMPLIANCE DOCUMENTS IN NEW ZEALAND.

THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

BY

NWADIKE AMARACHUKWU NNADOZIE

SUPERVISORS:

PROFESSOR SUZANNE WILKINSON

AND

PROFESSOR CHARLES CLIFTON

APRIL, 2019

Section A: Participant Information

1. Which of the following professional group applies to you?

   ○ Structural Engineer

   ○ Geotechnical Engineer

   ○ Architect

   ○ Building Services Consulting Engineer (such as Electrical engineer, Mechanical engineer, etc.)

   ○ Licenced Building Practitioner

   ○ Project Manager

   ○ Building Contractor

   ○ Local Authority

   ○ Academic/Researcher

   ○ Quantity Surveyor

   ○ Others, please specify……………………………………………………………………………………………………

2. How many years of professional experience do you have?

   ○ 0-5 ○ 6-10 ○ 11-15 ○ 16-20 ○ 21+

4. How would you describe the size of your organisation?

   ○ Large scale ○ Medium scale ○ Small scale

5. Which of these levels best describes your position within your organisation?

   ○ Director ○ Senior management ○ Middle management ○ Supervisor/team leader ○ Staff

6. How many years have you worked with your current organisation?

   ○ 0-1 ○ 1-5 ○ 6-10 ○ 11-15 ○ 16-20 ○ 21+

7. What is your level of familiarity with the New Zealand Building Code Compliance Documents?

   ○ Very low ○ Low ○ Medium ○ High ○ Very high

8. Which of the following locations do you work mostly?

   ○ Auckland ○ Wellington ○ Christchurch ○ Dunedin ○ Others, please specify ………………………

SECTION B: Post-disaster Reconstruction in New Zealand

1. How would you rate the current progress of the Christchurch post-disaster reconstruction? Please choose **ONLY one** option

   ◯ Very low ◯ low ◯ Moderate ◯ High ◯ Very high

2. Are you aware of all the building code compliance document updates relating to the 2011 Christchurch earthquake? Please choose **ONLY one** option

   ◯ Very much ◯ Somewhat ◯ Neutral ◯ Not much ◯ Not at all

3. The amended building code compliance documents have had a positive impact in New Zealand. Please choose **ONLY one** option

   ◯ Strongly Disagree ◯ Disagree ◯ Neutral ◯ Agree ◯ Strongly agree

4. Regular updates to building code and compliance documents without specified intervals causes confusion? Please choose **ONLY one** option

   ◯ Strongly Disagree ◯ Disagree ◯ Neutral ◯ Agree ◯ Strongly agree

5. Bureaucracy within the local council contributes to slowing down the post-disaster reconstruction process? Please choose **ONLY one** option

   ◯ Strongly Disagree ◯ Disagree ◯ Neutral ◯ Agree ◯ Strongly agree

6. There has been an improvement in the quality of construction due to building code compliance document amendments? Please choose **ONLY one** option.

   ◯ Strongly Disagree ◯ Disagree ◯ Neutral ◯ Agree ◯ Strongly agree

7. The following factors **NEGATIVELY** affects the **POST-DISASTER RECONSTRUCTION PROCESS**. To what extent do you agree or disagree? Please choose **ONLY one** option

	Factors	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
i.	Political factors					
ii.	Poor coordination issues					
iii.	Shortage of technical staff					
iv.	Lack of managerial expertise					
v.	Insufficient financial resource availability					
vi.	Shortage of construction material					
vii.	Unclear communication between stakeholders					
viii.	Waiting for design approval					
ix.	Waiting for inspection after work began					
x.	Unclear building code specifications/ details					
xi.	Waiting for building code consent					
xii.	Inadequate legislation for post-disaster reconstruction					
xiii.	Poor pre-disaster mitigation strategies					
xiv.	Inadequate human resources issues					
xv.	Poor implementation of pre-disaster plans					
xvi.	Poor monitoring of pre-disaster plan					
xvii.	Unclear recovery plan					
xvii.	Community induced delay					
xix.	Underestimated cost of construction					
xx.	Corruption					
xxi.	Cost overrun					

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
xxii.	Time limitation					
xxiii.	Contractors under pressure					
xxiv.	Poor land-use planning and implementation					
xxv.	Undefined reconstruction approach					
xxvi.	Institutional bureaucracy					
xxvii.	Pressure from the government for quick project completion					
	Others, please specify?					

8. The following have been understood to **NEGATIVELY (unintentionally)** affects **BUILDING CODE COMPLIANCE DOCUMENTS AMENDMENTS**. To what extent do you agree or disagree? Please choose **ONLY one** option

	Factors	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
i.	Poor implementation of code					
ii.	Poor work quality					
iii.	Changes in construction material					
iv.	Professional skills shortage					
v.	Non-professional skills shortage					
vi.	Insufficient financial resource availability					
vii.	Increase in the cost of design, construction, installation, etc.					
viii.	Poor of health and safety compliance					
ix.	Lack of training on building code compliance document updates					
x.	Environmental impacts					
xi.	Poor compliance with the building code					
xii.	Lenient enforcement of compliance with the building code updates					
xiii.	Property owners unwillingness to comply with the building code compliance document updates					
xiv.	Poor work environment					
xv.	Lack of competence in construction workers					
xvi.	Bureaucracy in the design approval process					
xvii.	Lack of incentives (assistance, financial etc.)					
xvii.	Poor working ethics					
xix.	Poor awareness creation					
xx.	Poor planning					
xxi.	Increased technical complexity in the building code					
xxii.	Acceptance of unsafe designs by authorities					
xxiii.	Poor site inspection					
xxiv.	Inadequate technical assistance to code users					
xxv.	Shortage of BCA technical staff for assistance					
	Others, please specify?					

9. The following have been understood to **POSITIVELY (benefits)** affects **BUILDING CODE COMPLIANCE DOCUMENT AMENDMENTs**. To what extent do you agree or disagree? Please choose **ONLY one** option.

	Benefits	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
i.	Improved resilient structures					
ii.	Flexibility in design and construction					
iii.	Innovation in design and construction					
iv.	Clear implementation process					
v.	Good work quality					
vi.	Improved material quality					
vii.	Increased professional skills					
viii.	Increased non- professional skills					
ix.	Planned resource availability					
x.	Reduction in cost of design, construction, installation etc.					
xi.	Improved Health and safety compliance					
xii.	Training on updated building code compliance document					
xiii.	Increased transferability of skills					
xiv.	Improved compliance with building code.					
xv.	Improved enforcement of the building code updates.					
xvi.	Increased willingness of property owners to comply					
xvii.	Encourage pre-disaster policies					
xvii.	Improved competence					
xix.	Increased international collaboration					
xx.	Reduced bureaucracy in the design approval process					
xxi.	Increased technical assistance to code users					
xxii.	Better awareness of building code amendments					
xxiii.	Stricter enforcement					
xxiv.	Reduced corruption tendencies					
xxv.	Improved construction method					
xxvi.	Improved resilience of the built environment					
xxvii.	Make way for low-cost material					
xxviii.	Promote local technology					
	Others, please specify?					

SECTION C: Building Code Compliance Documents Amendments

1. The existing **New Zealand Building Acts** itself needs amendment. To what extent do you agree? Please choose **ONLY one** option.

◯ Strongly Disagree ◯ Disagree ◯ Neutral ◯ Agree ◯ Strongly agree

2. The New Zealand Building Code Compliance Documents should be amended. To what extent do you agree? Please choose **ONLY one** option.

◯ Strongly Disagree ◯ Disagree ◯ Neutral ◯ Agree ◯ Strongly agree

3. Do you think that the amended Building Code Compliance Documents should be updated after any major disaster? Please choose **ONLY one** option

◯ Yes ◯ No

4. How often do you think the New Zealand Building Code Compliance Documents should be amended? Please choose **ONLY one** option.

◯ 1 year ◯ 2 years ◯ 3 years ◯ 4 years ◯ 5 years

5. Which of the following pathways do you think is preferable to use in updating New Zealand Building Code Compliance Documents?

◯ Intensive research ◯ Learning from previous disasters ◯ Others? Please specify ……………………………………………

6. How do you get information on any updates to New Zealand Building Code Compliance Documents?

◯ Colleagues/Friends ◯ MBIE website ◯ Employer ◯ Email ◯ Others? Please specify…………………………

7. How often do you visit the MBIE website to search for updates to the Building Code Compliance Documents? Please choose **ONLY one** option

◯ Always ◯ Often ◯ Sometimes ◯ Rarely ◯ Never

8. Do you believe that the Building Code updates should be made available to New Zealand's construction industry and the general public free of charge? Please choose **ONLY one** option

◯ Strongly Disagree ◯ Disagree ◯ Neutral ◯ Agree ◯ Strongly agree

SECTION D: Challenges acing Building Code Compliance

1. The following factors may affect **COMPLIANCE** with the Building Code during the post-disaster reconstruction. To what extent do you agree? Please choose **ONLY one** option

	Factors	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
i.	Lack of collaboration between stakeholder					
ii.	Lack of effective Building Code enforcement team					
iii.	Poor Building Code compliance mindset.					
iv.	Poor disaster risk reduction mindset					
v.	Poor understanding of Building Code Compliance Documents					
vi.	Poor training for code users					
vii.	No training needs assessment					
viii.	Lack of qualified technical staff					
ix.	Lack of compliance incentives					
x.	Complications in Building Code					
xi.	Building Code regulators neglect of relevant stakeholders					
xii.	Lack of capacity building					
xiii.	Lack of stakeholders engagement					
xiv.	Corruption in Building Code enforcement process					

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
xv.	Irregular Building Code update					
xvi.	Cost of compliance with Building Code					
xvii.	Poor awareness on the benefits of compliance					
xvii.	Poor awareness of the consequences of non-compliance					
xix.	Lack of concern for Building Code					
xx.	Lack of adequate capacity to enforce Building Code					
xxi.	Weak monitoring team					
xxii.	limited punishment for non-compliance					
xxiii.	Long wait for design approval					
xxiv.	Long wait for work inspection					

2. The following factors encourages Building Code compliance. To what extent do you agree? Please choose **ONLY one** option.

	Factors	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
i.	Professional technical skilled staff					
ii.	Training of code users					
iii.	Incentives					
iv.	Reduced compliance cost					
v.	Regular monitoring and inspection without notice					
vi.	Regular consultation					
vii.	Country-specific building codes					
viii.	Provide free or low-cost technical assistance					
ix.	Reduced bureaucracy					
x.	Sufficient resources for enforcement					
xi.	Severe punishment for repeated offenders					
	Others, please specify?					

DRIVERS FOR COMPLIANCE WITH THE BUILDING CODE

3. The following have been described as the drivers for compliance with the Building Code, to what extent do you agree or disagree? Please choose **ONLY one** option

	Factors	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
i.	Transparency/openness					
ii.	Fairness					
iii.	Accountability					
iv.	Efficiency					
v.	Consistency					
vi.	Trust					
vii.	Effectiveness					
	Others, please specify?					

4. Which of the following reconstruction approach do you consider more efficient in promoting compliance with Building Code?

◯ Owner- driven ◯ Contractor-driven ◯ Government-driven ◯ Cash approach ◯ Community driven

Thank you for your time

Please kindly leave your name and email, if you are willing to participate in an interview.

Name: ....

Email: ....

Please add any additional feedback:

....

....

For further enquiries, please contact:

- **Amarachukwu Nwadike Nnadozie** – PhD Student **|** Department of Civil and Environmental Engineering, the University of Auckland **|** Email: anwa156@aucklanduni.ac.nz
- **Prof Suzanne Wilkinson** – Supervisor **|** Department of Civil and Environmental Engineering, the University of Auckland **|** Email: s.wilkinson@auckland.ac.nz
- **Prof. Charles Clifton** – Supervisor **|** Department of Civil and Environmental Engineering, the University of Auckland **|** Email: c.clifton@auckland.ac.nz

Questionnaire distributed under University of Auckland
Ethics Code Compliance: **021894**

Appendix 2: Interview question

1. Based on your understanding, do you think that New Zealand Building Code (NZBC) needs improvement?
2. What is your perception on the developed evidence-based framework?
3. Do you think that the evidence-based framework addresses the issue of New Zealand building code improvement?
4. What are the areas in the building code that needs improvement?
5. What are the areas that need to be improved in building code regulation and administration?
6. What are the areas that need to be improved in building code design and implementation?
7. What are the areas that need to be improved in building code enforcement?
8. What are the areas that need to be improved in building code compliance?
9. What are the areas that need to be improved in building code amendment process?

Appendix 3: Records of New Zealand building code amendment

Record of amendments

Updated January 2020

BUILDING PERFORMANCE

Acceptable Solutions and Verification Methods, and Handbooks (1993 - 2019)	2019	2018	2017	2016	2014	2013	2012	2011	2010	2009	2008	2007	2005	2004	2003	2002	2001	2000	1998	1995	1994	1993
Building Code Handbook	-	-	-	-	Am 13	-	-	Am 12	Am 11	-	-	3rd ed	-	Am 9	Am 8	Am 7	Am 6	Am 5	Am 4	2nd ed	Am 2	Am 1
Compliance Schedule Handbook	-	-	-	-	Am 3	-	-	Am 2	-	-	Am 1	New doc										
Back Country Huts	-	-	-	-	Am 1	-	-	-	-	New doc												
Simple House	Discontinued	-	-	-	-	-	-	-	New doc													
B1 Structure	Am 18 Am 19	Am 16 Am 17	Am 15	Am 13 Am 14	Am 12	-	-	Am 10 Am 11	Am 9 Err 1	-	Am 8	Am 7	Am 6	-	-	-	Am 5 Err	Am 4	-	Am 3	Am 2	Am 1
B2 Durability	Am 11 Am 12	Am 10	Am 9	-	Am 8	-	-	Am 7	Am 6	-	-	-	-	Am 4 Am 5	-	-	Am 3	Am 2	2nd ed	-	-	Am 1
C1-C6 Protection from Fire																						
C/AS2 Buildings other than Risk Group SH	New doc Err 1 Am 1																					
C/VM1 Solid Fuel Appliances	-	-	Am 4	-	Am 3	Err 1 Am 2	New doc															
C/AS1 Sleeping (residential) and Outbuildings (Risk Group SH)	-	-	Am 4	-	Am 3	Err 1 Am 2	New doc															
C/AS2 Sleeping (non institutional) (Risk Group SM)	Discontinued	-	Am 4	-	Am 3	Err 1 Am 2	New doc															
C/AS3 Care or Detention (Risk Group SI)	Discontinued	-	Am 4	-	Am 3	Err 1 Am 2	New doc															
C/AS4 Public Access and Educational Facilities (Risk Group CA)	Discontinued	-	Am 4	-	Am 3	Err 1 Am 2	New doc															
C/AS5 Business, Commercial and Low Level Storage (Risk Group WB)	Discontinued	-	Am 4	-	Am 3	Err 1 Am 2	New doc															
C/AS6 High Level Storage and Other High Risk Purposes (Risk Group WS)	Discontinued	-	Am 4	-	Am 3	Err 1 Am 2	New doc															
C/AS7 Vehicle Storage and Parking (Risk Group VP)	Discontinued	-	Am 4	-	Am 3	Err 1 Am 2	New doc															
C/VM2 Framework for Fire Safety Design	-	-	Am 5	-	Am 4	Am 2 Am 3	New doc Err 1															
C Fire safety (amalgamation of C1-C4)							Discontinued	Am 9	Am 8	-	Am 7	Am 6	Am 4 Am 5	Am 3	Am 2	Am 1	-	New doc Err				
C1 Outbreak of fire																		Discontinued	Am 2	-	Am 1	-
C2 Means of escape																		Discontinued	-	2nd ed	Am 2	Am 1
C3 Spread of fire																		Discontinued	-	3rd ed	Am 2 Err 1	2nd ed
C4 Structural stability during fire																		Discontinued	-	3rd ed	Am 2 Err 1	2nd ed
D1 Access routes	-	-	Am 6	-	-	-	-	Am 5	-	-	-	-	-	-	-	-	Am 4	-	2nd ed	Am 3	Am 2	Am 1
D2 Mechanical installations for access	-	-	Am 7	-	Am 5	-	-	-	-	-	-	-	-	-	-	2nd ed	-	-	Am 4	Am 3	Am 2	Am 1
E1 Surface water	-	-	Am 10	-	Am 9	-	-	Am 8	Am 7	-	-	-	-	-	-	Am 6	Am 5	Am 4	-	Am 3	Am 2	Am 1
E2 External moisture																						
E2/AS4 Citation of National Association of Steel Frame Housing Enclosure Standard	New doc																					
E2/VM2 Cladding systems for buildings up to 25 m in height – including junctions with windows, door and other penetrations	New doc																					
E2/VM1, E2/AS1, E2/AS2 and E2/AS3 (titled E2 External moisture prior to June 2019)	Am 9	Am 8	Am 7	-	Am 6	-	-	Am 5 Err 2	-	-	Am 4	Am 3	Am 2 Err 1	Am 5 3rd ed Am 1	-	-	Am 4	Am 3	2nd ed	-	Am 2 Err 1	Am 1
E3 Internal moisture	-	-	Am 6	-	Am 5	-	-	Am 4	-	-	-	-	-	Am 3	-	-	Am 2	-	2nd ed	-	-	Am 1
F1 Hazardous agents on site	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Am 1	-	-	-	-	-
F2 Hazardous building materials	-	-	Am 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Am 2	-	-	Am 1	-
F3 Hazardous substances and processes	-	-	-	-	-	-	-	-	-	-	-	2nd ed	-	-	-	-	Am 1	-	-	-	-	-
F4 Safety from falling	-	-	Am 2	-	-	-	-	-	-	-	-	3rd ed Am 1	-	-	-	Am 4	-	-	2nd ed	Am 3	Am 2	Am 1
F5 Construction and demolition hazards	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F6 Visibility in escape routes	-	-	Am 4	-	Am 3	-	-	Am 2	-	-	-	Am 1 3rd ed	-	-	-	-	2nd ed	-	-	Am 1	-	-
F7 Warning systems	-	-	-	-	-	-	4th ed	Am 7	-	-	Am 6	-	Am 5	-	Am 4	-	-	3rd ed	-	Am 3	Am 2	2nd ed
F8 Signs	-	-	Am 4	-	Am 3	-	2nd ed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Am 1
F9 Restricting access to residential pools	-	-	New doc																			
G1 Personal hygiene	-	-	-	-	-	-	-	Am 6	-	-	-	Am 5 Err 1	-	-	-	-	Am 4	2nd ed	-	Am 3	Am 2	Am 1
G2 Laundering	-	-	Am 3	-	-	-	-	Am 2	-	-	-	-	-	-	-	-	Am 1	-	-	-	-	-
G3 Food preparation and prevention of contamination	-	-	Am 2	-	-	-	-	-	-	-	-	-	-	-	-	-	Am 1	-	-	-	-	-
G4 Ventilation	4th ed	-	Am 4	-	Am 3	-	-	Am 2	-	-	3rd ed	Am 1	-	-	-	-	-	-	2nd ed	-	-	Am 1
G5 Interior environment	-	-	-	-	-	-	-	Am 2	-	-	-	-	-	-	-	-	Am 1	-	-	-	-	-
G6 Airborne and impact sound	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Am 2	Am 1	-
G7 Natural light	-	-	-	-	Am 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Am 1	-	-
G8 Artificial light	-	-	-	-	Am 2	-	-	-	-	-	-	-	-	-	-	-	Am 1	-	-	-	-	-
G9 Electricity	-	-	-	-	Am 6	-	-	-	Am 5	-	-	Am 4	-	-	-	-	Am 3	-	-	Am 2	-	Am 1
G10 Piped services	-	-	Am 8	-	Am 7	-	-	Am 6	Am 5	-	-	Am 4	-	-	-	-	-	-	Am 3	Am 2	-	Am 1
G11 Gas as an energy source	-	-	Am 6	-	Am 5	-	-	-	Am 4	-	-	Am 3	-	-	-	-	-	-	Am 2	-	-	Am 1

Record of amendments

Updated January 2020

G12 Water supplies	Am 12	Am 11	Am 10	-	Am 9	-	-	Am 8	Am 7	-	-	Am 6 3rd ed	-	Am 5	-	Am 4	2nd ed	-	-	Am 3	Am 2	Am 1
G13 Foul water	Am 8	Am 7	Am 6	-	Am 5	-	-	Am 4	Am 3	-	-	Am 1 Err 1 Am 2	-	-	-	-	2nd ed	-	Am 3	Am 2	-	Am 1
G14 Industrial liquid waste	-	-	Am 6	-	Am 5	-	-	Am 4	Am 3	-	-	2nd ed	-	-	-	-	-	-	-	Am 2	-	Am 1
G15 Solid waste	-	-	-	-	-	-	-	-	Am 3	-	-	-	-	-	-	-	Am 2	-	-	-	-	Am 1
H1 Energy efficiency	Am 4	-	4th ed Am 3	-	-	-	-	Am 2	-	-	-	3rd ed	-	-	-	-	Am 1	2nd ed	-	-	-	-

Key: Am = Amendment, ed = Edition, Err = Errata

Appendix 4a: Participant information sheet (**Questionnaire**)

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
Faculty of Engineering

The University of Auckland
Private Bag 92019
Auckland, New Zealand
Engineering Building
20 Symonds Street,
Auckland, New Zealand
Telephone 64 9 3737599 ext 88166
www.cee.auckland.ac.nz

PARTICIPANT INFORMATION SHEET (PIS) FOR QUESTIONNAIRE

Research Project Title: Impacts of building code amendment in New Zealand

Reference: 021894

Name of Researcher: Nwadike Amarachukwu Nnadozie

Degree: PhD Candidate

Department: Civil & Environmental Engineering

Research Supervisor: Professor Suzanne Wilkinson

Researcher Introduction

My name is Nwadike Amarachukwu Nnadozie, I am a doctoral student in the Department of Civil and Environmental Engineering at the University of Auckland. My supervisor is Professor Suzanne Wilkinson Jane.

The project

Rationale: The reason behind this research work is to identify and assesses the impact of rebuilding cities in New Zealand with amended building code in post-disaster reconstruction. The outcome of this research work will help to reduce the impact of building code amendment in rebuilding cities in New Zealand.

Aim: The research goal is to assess and identify the impact of building code amendment in rebuilding cities in New Zealand with emphasis in Christchurch. The research also aim to provide ways to improve the impact of building code updates to achieve a disaster reduced built environment.

Duration: The research will continue for three years.

Benefits: The researcher and the supervisor expects that the results from the project will help to provide solutions to the impact of building code amendment in rebuilding New Zealand cities. In addition, the recommendations will also help to achieve the aims and objectives of disaster risk reduction in the built environment.

Risks: We have identified that some of the risks associated with this research are very minimal. For you, as a participant, there is no risk. Should there be any adverse effects as a result of this survey the University of Auckland Human Participants Ethics Committee will be informed.

Funding: The research work does not have any funding. The researcher is a self-sponsored student.

Invitation to participate

Why: You are invited to participate in this research to provide your unbiased opinion related to the impact of building code amendment in New Zealand with emphasis in rebuilding cities.

How: To find potential participants, like you, we have identified the New Zealand construction industry and the building code regulatory bodies. You have been selected because of your vast knowledge and experience in building code updates, post-disaster reconstruction process and disaster risk reduction in New Zealand.

Voluntary participation: Your participation is voluntary and you may decline this invitation to participate without penalty. Your identity will be kept anonymous and confidential. We do not collect any information such as your name, email address or phone number. By consenting to completion of this survey, you give us permission to use your answers in research publications, PhD thesis, Conference papers and any other academic related events.

We are requesting for the permission of the executive director (Officer)/ Manager to administer our academic questionnaires to the staff members of the company. We assure the participants that their participation will not affect their relation with the organization (company) and its leaders.

Venue: The survey will take place in your company. The researcher will travel to your company to administer the questionnaires.

Time: The questionnaire will be shared to you at your convenience in your company.

Time to complete the survey: The time to complete the survey is estimated to be 30 minutes.

Procedure: The researcher will approach the executive director (officer)/ manager of your company, who will approve and distribute the questionnaire to you (the employee's). By filling this questionnaire, we take it as having the consent of the employee's.

Project procedures

If you choose to participate, you will be asked to complete a written questionnaire. The expected time to complete the questionnaire is about 30 minutes. You can choose to withdraw from participation at any time by verbally stating your withdrawal.

Data storage, Retention, Destruction and Future use

How: We will collect the data by using your answers from the completed questionnaire.

Where: The data collected will be stored under the University of Auckland's IT system, in a computer which is protected by password.

How long: The data will be stored for a minimum of six years.

Destruction: After the minimum storage time has elapsed, the hard-copy data such as the consent form and the questionnaire will be stored within the cabinet of the University of Auckland (in the PI's office).

Right to withdraw from participation

You have the right to withdraw from the questionnaire at any time without giving a reason and you can withdraw your data up to the completion of the questionnaire. Please note that the withdrawal of individual data is not possible after the questionnaire has been completed and submitted to the research as the questionnaire is anonymous and therefore will not be able to be identified.

Anonymity and Confidentiality

The preservation of confidentiality is paramount. The information you share with us will remain confidential to the researcher and supervisor in relation to this project. Confidentiality will be maintained to the extent of the law. The questionnaire do not request for information's such as your name, email address or phone number. If the information you provided will be reported or published, this will be done in such a way that its source cannot be identified.

The summary of the findings that are written in a non-academic language will be made available to the participants on request. Such participants will be asked to provide their postal or email address in the provided column.

I wish to receive a summary of findings, which can be emailed to me at this email address: ____

For further inquiries regarding this research, please do not hesitate to contact the following people, using the box below:

Contact details and approval

Student Researcher name and contact details	**Supervisor name and contact details**	**Head of Department Name and Contact Details**
Nwadike Amarachukwu Nnadozie. Department of Civil and Environmental Engineering anwa156@aucklanduni.ac.nz Phone: +64 2041669067	Professor Suzanne Wilkinson Department of Civil and Environmental Engineering s.wilkinson@auckland.ac.nz Phone: +64 9 9238184	Professor Jason Maxwell Ingham Department of Civil and Environmental Engineering Email: j.ingham@auckland.ac.nz Phone: +64 99237803

For any queries regarding ethical concerns you may contact the Chair, The University of Auckland Human Participants Ethics Committee, The University of Auckland, Research Office, Private Bag 92019, Auckland 1142. Telephone 09 373-7599 ext. 83711. Email: ro-ethics@auckland.ac.nz

Approved by the University of Auckland Human Participants Ethics Committee on ________________________ for three years, Reference Number 021894

Appendix 4: Participant information sheet (**Interview**)

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
Faculty of Engineering

The University of Auckland
Private Bag 92019
Auckland, New Zealand
Engineering Building
20 Symonds Street,
Auckland, New Zealand
Telephone 64 9 3737599 ext 88166
www.cee.auckland.ac.nz

PARTICIPANT INFORMATION SHEET (PIS) FOR INTERVIEW

Research Project Title: Impacts of building code amendment in New Zealand

Reference: 021894

Name of Researcher: Nwadike Amarachukwu Nnadozie

Degree: PhD Candidate

Department: Civil & Environmental Engineering

Research Supervisor: Professor Suzanne Wilkinson

Researcher Introduction

My name is Nwadike Amarachukwu Nnadozie, I am a doctoral student in the Department of Civil and Environmental Engineering at the University of Auckland. My supervisor is Professor Suzanne Wilkinson Jane.

The project

Rationale: The reason behind this research work is to identify and assesses the impact of rebuilding cities in New Zealand with amended building code in post-disaster reconstruction. The outcome of this research work will help to reduce the impact of building code amendment in rebuilding cities in New Zealand.

Aim: The research goal is to assess and identify the impact of building code amendment in rebuilding cities in New Zealand with emphasis in Christchurch. The research also aim to provide ways to improve the impact of building code updates to achieve a disaster reduced built environment.

Duration: The research will continue for three years.

Benefits: The researcher and the supervisor expects that the results from the project will help to provide solutions to the impact of building code amendment in rebuilding New Zealand cities. In addition, the recommendations will also help to achieve the aims and objectives of disaster risk reduction in the built environment

Risks: We have identified that some of the risks associated with this research are very minimal. For you, as a participant, there is no risk. Should there be any adverse effects as a result of this survey the University of Auckland Human Participants Ethics Committee will be informed.

Funding: The research work does not have any funding. The researcher is a self-sponsored student.

Invitation to participate

Why: You are invited to participate in this research to provide your unbiased opinion related to the impact of building code amendment in New Zealand with emphasis in rebuilding cities.

How: To find potential participants, like you, we have identified the New Zealand construction industry and the building code regulatory bodies. You have been selected because of your vast knowledge and experience in building code updates, post-disaster reconstruction process and disaster risk reduction in New Zealand.

Voluntary participation: Your participation is voluntary and you may decline this invitation to participate without penalty. Your identity will be kept anonymous and confidential. We do not collect any information such as your name, email address or phone number. By consenting to participate in the interview, you give us permission to use your answers in research publications, PhD thesis, conference papers, research poster, journal papers and any other academic related events.

Permission: We are requesting for the permission of the executive director (Officer)/ Manager to conduct our academic interview with the staff members of your company. We assure the participants that their participation will not affect their relation with the organization (company) and its leaders.

Venue: The interview will take place in your company. The researcher will travel to your company to conduct the interview.

Time: The interview will be conducted at your convenience in your company.

Time to complete the survey: The interview will last for about 45 minutes.

Procedure: The researcher will approach the executive director (officer)/ manager of your company, who will approve the interview and inform the employee's. By participating in the interview, we take it as having the consent of the employee's.

Project procedures

If you choose to participate, you will be asked to sign the consent form. The expected time for the interview is about 45 minutes. You can choose to withdraw from participation at any time by verbally stating your withdrawal during the interview. After the interview, the participants will be given their transcripts for review and editing (minor). This will be their final opportunity to check their responses or withdraw within 7 to 14 days of receiving their transcript, after which they cannot withdraw their contributions again. With your permission, the interview will be audio-record. Even if you agree to be recorded, you may choose to have the recorder turned off at any time.

Data storage, Retention, Destruction and Future use

How: We will collect the data by using your answers from the open-ended interview questions.

Where: The data collected will be stored under the University of Auckland's IT system, in a computer which is protected by password.

How long: The data will be stored for a minimum of six years.

Destruction: After the minimum storage time has elapsed, the data will be destroyed by deleting the files. The hard-copy data such as the consent form will be stored within the cabinet of the University of Auckland (in the PI's office).

Right to withdraw from participation

You have the right to withdraw from the interview at any time without giving a reason and you can withdraw your data up to the completion of the interview. After the interview, the participants will be given their transcripts for review and editing (minor). This will be their final opportunity to check their responses, withdraw or return the edited transcript within 7 to 14 days of receiving their transcript, after which they cannot withdraw their contributions again.

Anonymity and Confidentiality

The preservation of confidentiality is paramount. The information you share with us will remain confidential to the researcher and supervisor in relation to this project. Confidentiality will be maintained to the extent of the law. The researcher do not request for information's such as your name, email address or phone number during the interview. If the information you provided will be reported or published, this will be done in such a way that its source cannot be identified.

The summary of the findings that are written in a non-academic language will be made available to the participants on request. Such participants will be asked to provide their postal or email address in the provided column.

I wish to receive a summary of findings, which can be emailed to the researcher at this email address:

For further inquiries regarding this research, please do not hesitate to contact the following people, using the box below:

Contact details and approval

Student Researcher name and contact details	**Supervisor name and contact details**	**Head of Department Name and Contact Details**
Nwadike Amarachukwu Nnadozie. Department of Civil and Environmental Engineering anwa156@aucklanduni.ac.nz Phone: +64 2041669067	Professor Suzanne Wilkinson Department of Civil and Environmental Engineering s.wilkinson@auckland.ac.nz Phone: +64 9 9238184	Professor Jason Maxwell Ingham Department of Civil and Environmental Engineering Email: j.ingham@auckland.ac.nz Phone: +64 99237803

For any queries regarding ethical concerns you may contact the Chair, The University of Auckland Human Participants Ethics Committee, The University of Auckland, Research Office, Private Bag 92019, Auckland 1142. Telephone 09 373-7599 ext. 83711. Email: ro-ethics@auckland.ac.nz

Approved by the University of Auckland Human Participants Ethics Committee on ______________________ for three years, Reference Number 021894

Appendix 5: Consent form

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
Faculty of Engineering

The University of Auckland
Private Bag 92019
Auckland, New Zealand

Engineering Building
20 Symonds Street,
Auckland, New Zealand
Telephone 64 9 3737599 ext 88166
www.cee.auckland.ac.nz

CONSENT FORM FOR EXECUTIVE OFFICER / MANAGER

(THIS FORM WILL BE HELD FOR A PERIOD OF 6 YEARS)

Research Project Title: **Impacts of building code amendment in New Zealand**

Reference: 021894

Researcher: Nwadike Amarachukwu Nnadozie

Degree: PhD Candidate

Email: anwa156@aucklanduni.ac.nz

Research Supervisors: Professor Suzanne Wilkinson
s.wilkinson@auckland.ac.nz

Invitation: I am writing to request for the permission of the executive officer/manager to interview your staff members. The interview will be based on challenges facing building code updates in reconstruction of cities in New Zealand. Furthermore, I am assuring you that participation of your employees will not affect their relation with your company and its leaders.

I have read the Participant Information Sheet (PIS), and I have understood the nature of the research and why I have been invited. I have had the opportunity to ask questions and have them answered to my satisfaction.

- I voluntarily agree to participate in this research
- I understand that I am free to withdraw my participation at any time, and to withdraw any data traceable to me up to a specified date without giving a reason (Within 7 to 14

days of receiving my interview transcript for editing, After which, I cannot withdraw my contributions)

- I agree to be audio recorded.
- I wish to receive a transcript of my interview for editing.
  [email:____]
- I understand that the audio recording under my permission will be transcribed by the researcher and a third party, who have signed a confidentiality agreement form.
- I agree to not disclose anything discussed in the interview
- I agree that the findings from this research project will be published without revealing my identity. The findings will be used in publications like PhD thesis, conference papers, research posters, journals papers and any other academic related events.
- I wish / I do not wish to receive a summary of findings written in a non-academic language, which can be emailed to me at this email address:

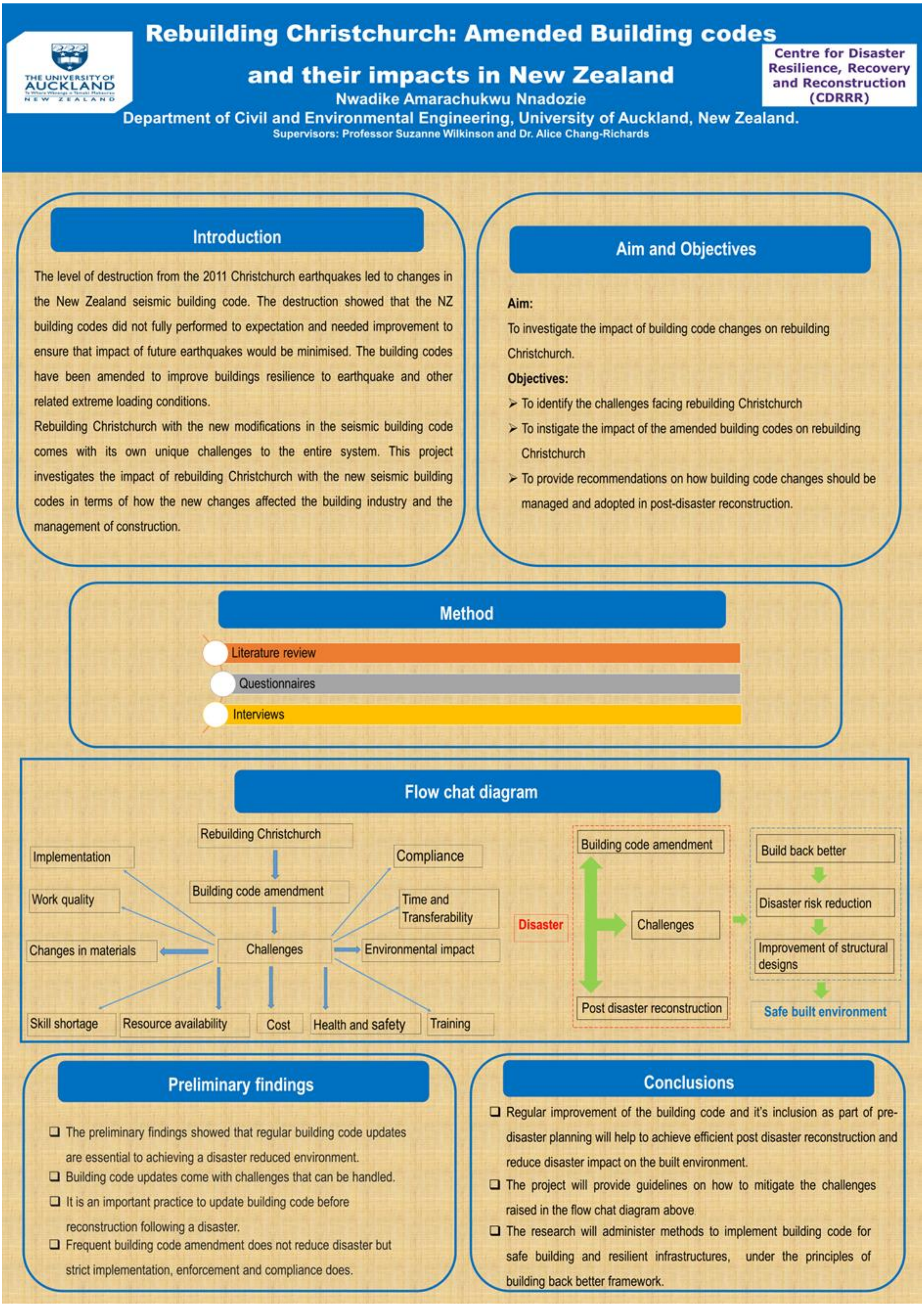
Signature: ___________________________ Date: _______________________

Name: ____

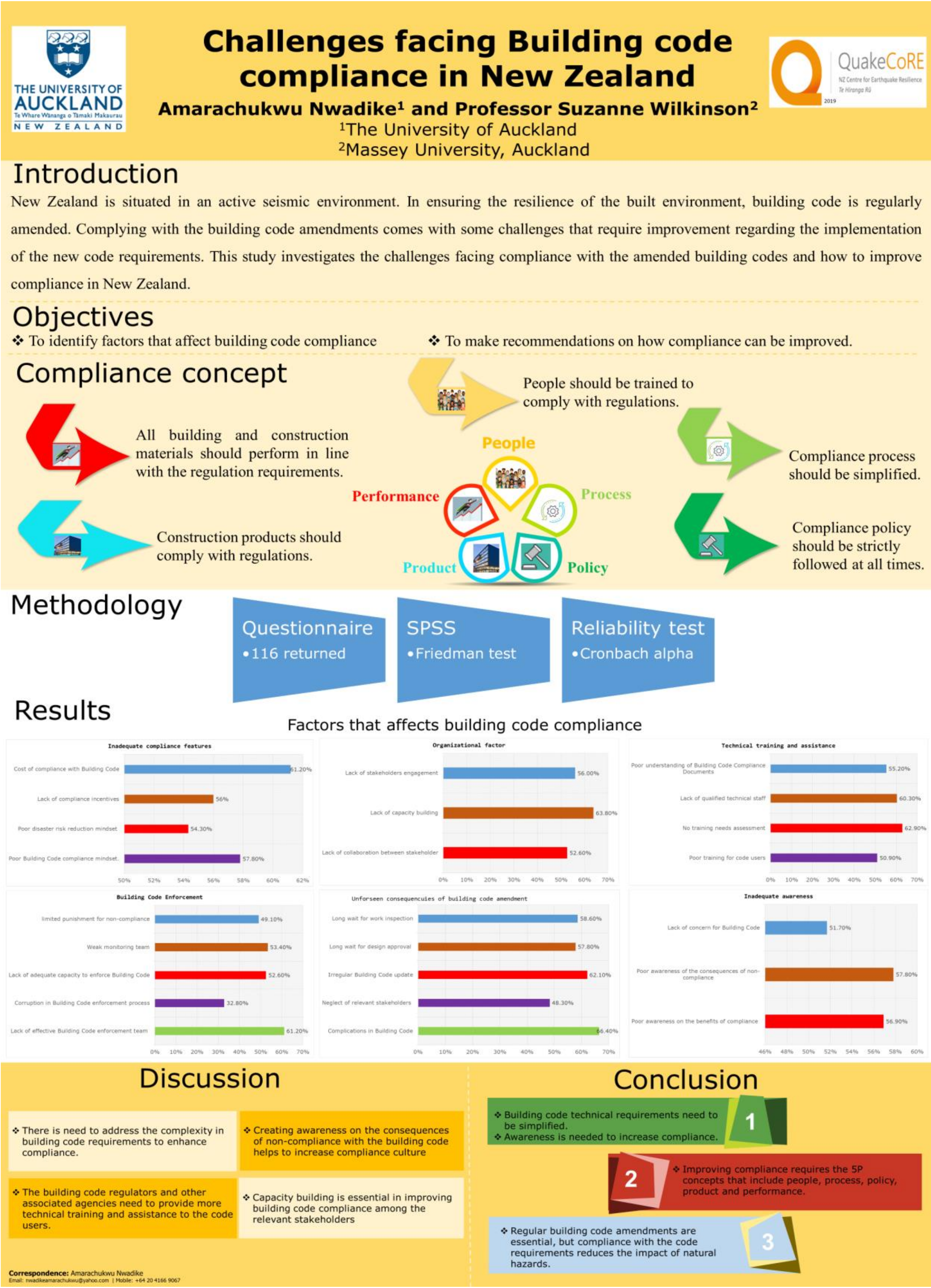
Email:____

Approved by the University of Auckland Human Participants Ethics Committee on __________for three years, Reference Number: 021894

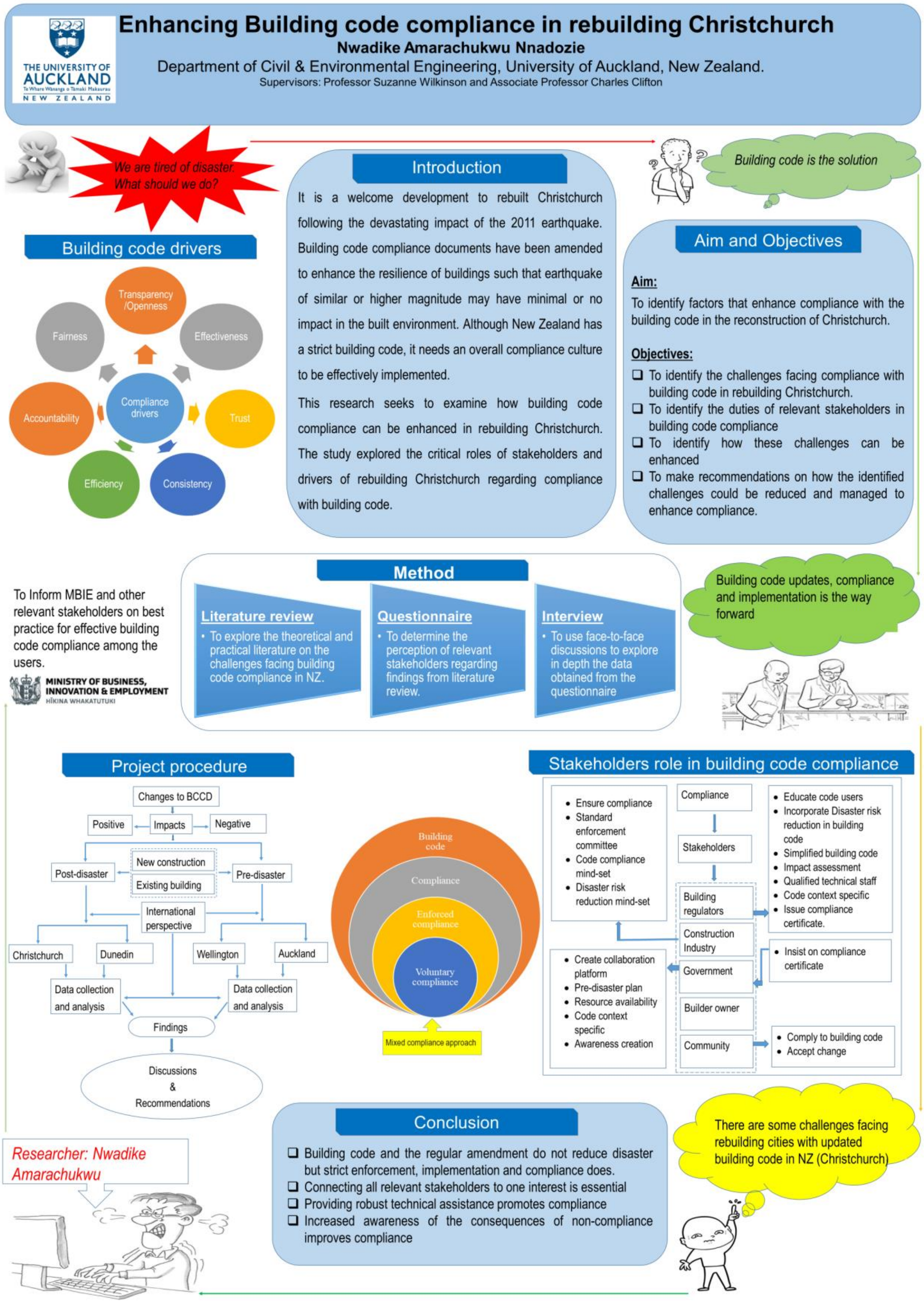
Appendix 6: 2018 QuakeCORE Conference Poster



Appendix 7: 2019 QuakeCORE Conference Poster



Appendix 8: 2019 PCEE Conference Poster



Appendix 9: 2020 QuakeCORE Conference Poster

An Evidence-based framework validation for Building code Improvement in New Zealand.

Amarachukwu Nwadike and Suzanne Wilkinson
School of Built Environment, Massey University, Auckland

Introduction

New Zealand building code may be serving its purpose to an extent; however, recent developments shows that there is still a need to improve the use and application of the building code for better building performance and services. An evidence-based framework was developed based on the identified parameters through qualitative and quantitative studies to improve the building code practice in New Zealand. This study aims to validate the identified parameters in the developed evidence-based framework to enhance building code practice.

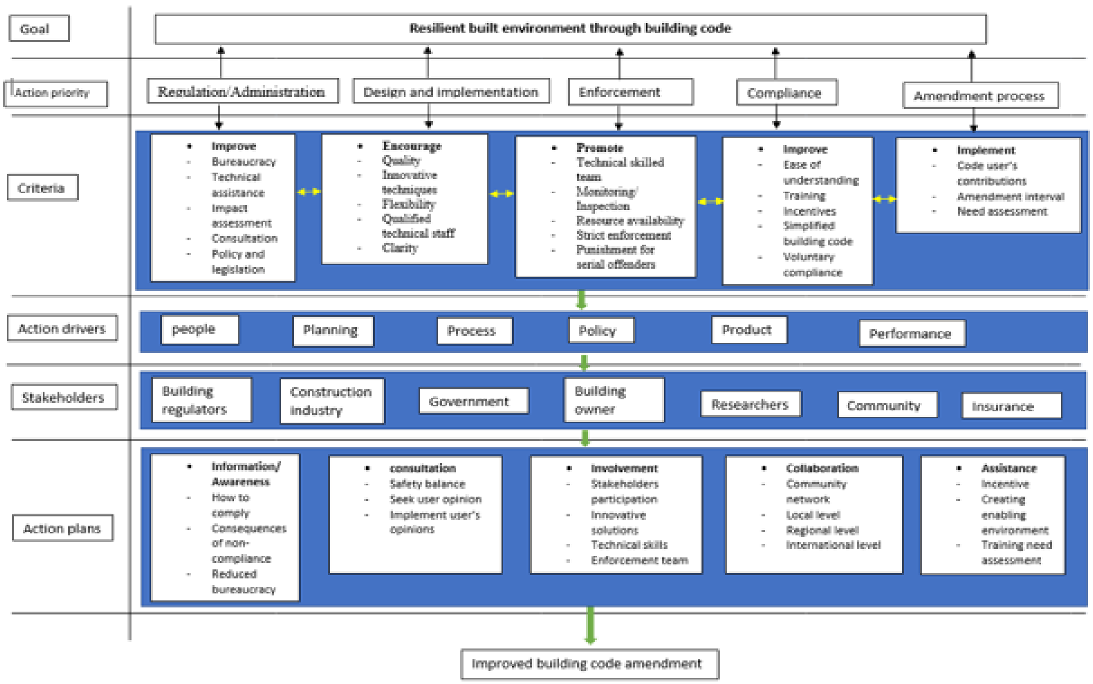
Objectives

- ❖ To validate an evidence-based framework
- ❖ To make recommendations on improving the building code.

Methodology

- ❖ Interview with subject matter experts (SME's)
- ❖ NVIVO software

Evidence-based framework



Results

Discussion

❖ Proactive training, educating, attractive incentives, awareness and providing adequate technical assistance to the code users.

❖ Enabling individuals with the required technical competency at different building policy decision-making levels of building regulatory system.

❖ Establishing an active enforcement process with qualified personnel adequate monitoring and inspection of building works rather than waiting for legal actions against the building code violators.

❖ encourage regular building code amendment centered on user friendly with an intent to ease compliance with building code.

Conclusion

1 ❖ The necessity of having competent technical building officers who can rightly review building applications.

2 ❖ Improving clarity in building code requirements to reduce complexities, especially defining the bare minimum standards recommended in the building code.

3 ❖ Although the SME's were divided in encouraging low-risk innovative techniques, all their contributions point towards promoting reasonable innovative solutions that are achievable and in line with the building officers and code user's knowledge.

Correspondence: Amarachukwu Nwadike

https://ir.canterbury.ac.nz/bitstream/handle/10092/101404/POSTER%20-%20Nwadike_Validation%20of%20a%20framework%20to%20improve%20building%20code%20amendment%20in%20New%20Zealand.pdf?sequence=1

Appendix 10: Statement of contribution to publications

DRC 16

MASSEY UNIVERSITY
GRADUATE RESEARCH SCHOOL

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Amarachukwu Nnadozie Nwadike
Name/title of Primary Supervisor:	Professor Suzanne Wilkinson
Name of Research Output and full reference:	
Comparative insight on building code paradigm shift practice and updates: International perspectives	
In which Chapter is the Manuscript /Published work:	Chapter 2
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	90%
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
Literature search, data collection, data analysis and drafted the first manuscript	
For manuscripts intended for publication please indicate target journal:	
Published in the International Conference on Civil, Structural and Transportation pro	
Candidate's Signature:	Amarachukwu Nnadozie Nwadike — Digitally signed by Amarachukwu Nnadozie Nwadike Date: 2021.04.15 07:59:57 +12'00'
Date:	15/04/2021
Primary Supervisor's Signature:	suzanne — Digitally signed by suzanne DN: cn=suzanne, c=NZ, o=massey, ou=massey, email=s.wilkinson@massey.ac.nz Date: 2021.04.28 13:41:18 +12'00'
Date:	28/04/2021

(This form should appear at the end of each thesis chapter/section/appendix submitted as a manuscript/ publication or collected as an appendix at the end of the thesis)

GRS Version 4– January 2019

DRC 16

MASSEY UNIVERSITY
GRADUATE RESEARCH SCHOOL

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Amarachukwu Nnadozie Nwadike
Name/title of Primary Supervisor:	Professor Suzanne Wilkinson
Name of Research Output and full reference:	
Impacts of innovation in performance-based building code	
In which Chapter is the Manuscript /Published work:	Chapter 3
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	90%
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
Literature search, data collection, data analysis and drafted the first manuscript	
For manuscripts intended for publication please indicate target journal:	
Published in New Zealand Society for Earthquake Engineering (NZSEE) Annual Tec	
Candidate's Signature:	Amarachukwu Nnadozie Nwadike Digitally signed by Amarachukwu Nnadozie Nwadike Date: 2021.04.15 08:06:21 +12'00'
Date:	15/04/2021
Primary Supervisor's Signature:	suzanne Digitally signed by suzanne DN: cn=suzanne, c=NZ, o=massey, ou=massey, email=s.wilkinson@massey.ac.nz Date: 2021.04.28 13:43:24 +12'00'
Date:	28/04/2021

(This form should appear at the end of each thesis chapter/section/appendix submitted as a manuscript/ publication or collected as an appendix at the end of the thesis)

GRS Version 4– January 2019

DRC 16

MASSEY UNIVERSITY
GRADUATE RESEARCH SCHOOL

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Amarachukwu Nnadozie Nwadike
Name/title of Primary Supervisor:	Professor Suzanne Wilkinson
Name of Research Output and full reference:	
Building code amendment process: A case study of New Zealand	
In which Chapter is the Manuscript /Published work:	Chapter 4
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	90%
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
Literature search, data collection, data analysis and drafted the first manuscript	
For manuscripts intended for publication please indicate target journal:	
Published in the 9th International Conference on Building Resilience proceedings	
Candidate's Signature:	Amarachukwu Nnadozie Nwadike Digitally signed by Amarachukwu Nnadozie Nwadike Date: 2021.04.15 08:14:20 +12'00'
Date:	15/04/2021
Primary Supervisor's Signature:	suzanne Digitally signed by suzanne DN: cn=suzanne, c=NZ, o=massey, ou=massey, email=s.wilkinson@massey.ac.nz Date: 2021.04.28 13:43:55 +12'00'
Date:	28/04/2021

(This form should appear at the end of each thesis chapter/section/appendix submitted as a manuscript/ publication or collected as an appendix at the end of the thesis)

GRS Version 4– January 2019

DRC 16

MASSEY UNIVERSITY
GRADUATE RESEARCH SCHOOL

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Amarachukwu Nnadozie Nwadike
Name/title of Primary Supervisor:	Professor Suzanne Wilkinson
Name of Research Output and full reference:	
Building code amendment and building resilience: Perspective of building code users in New Zealand	
In which Chapter is the Manuscript /Published work:	Chapter 5
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	90%
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
Literature search, data collection, data analysis and drafted the first manuscript	
For manuscripts intended for publication please indicate target journal:	
Published in Built Environment Project and Asset Management Joumal	
Candidate's Signature:	Amarachukwu Nnadozie Nwadike Digitally signed by Amarachukwu Nnadozie Nwadike Date: 2021.04.15 08:21:33 +12'00'
Date:	15/04/2021
Primary Supervisor's Signature:	suzanne Digitally signed by suzanne DN: cn=suzanne, c=NZ, o=massey, ou=massey, email=s.wilkinson@massey.ac.nz Date: 2021.04.28 13:44:33 +12'00'
Date:	28/04/2021

(This form should appear at the end of each thesis chapter/section/appendix submitted as a manuscript/ publication or collected as an appendix at the end of the thesis)

GRS Version 4– January 2019

DRC 16

MASSEY UNIVERSITY
GRADUATE RESEARCH SCHOOL

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Amarachukwu Nnadozie Nwadike
Name/title of Primary Supervisor:	Professor Suzanne Wilkinson
Name of Research Output and full reference:	
Why amending building codes? An investigation of the benefits of regular building code amendment in New Zealand	
In which Chapter is the Manuscript /Published work:	Chapter 6
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	90%
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
Literature search, data collection, data analysis and drafted the first manuscript	
For manuscripts intended for publication please indicate target journal:	
Published in International Journal of Building Pathology and Adaptation	
Candidate's Signature:	Amarachukwu Nnadozie Nwadike Digitally signed by Amarachukwu Nnadozie Nwadike Date: 2021.04.15 08:26:28 +12'00'
Date:	15/04/2021
Primary Supervisor's Signature:	suzanne Digitally signed by suzanne DN: cn=suzanne, c=NZ, o=massey, ou=massey, email=s.wilkinson@massey.ac.nz Date: 2021.04.28 13:44:58 +12'00'
Date:	28/04/2021

(This form should appear at the end of each thesis chapter/section/appendix submitted as a manuscript/ publication or collected as an appendix at the end of the thesis)

GRS Version 4– January 2019

MASSEY UNIVERSITY
GRADUATE RESEARCH SCHOOL

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Amarachukwu Nnadozie Nwadike
Name/title of Primary Supervisor:	Professor Suzanne Wilkinson
Name of Research Output and full reference:	
Unintended consequences of building code amendment in New Zealand	
In which Chapter is the Manuscript /Published work:	Chapter 7
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	90%
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
Literature search, data collection, data analysis and drafted the first manuscript	
For manuscripts intended for publication please indicate target journal:	
Submitted to Construction Innovation: Information, Process, Management Journal	
Candidate's Signature:	Amarachukwu Nnadozie Nwadike — Digitally signed by Amarachukwu Nnadozie Nwadike Date: 2021.04.15 08:31:30 +12'00'
Date:	15/04/2021
Primary Supervisor's Signature:	suzanne — Digitally signed by suzanne DN: cn=suzanne, c=NZ, o=massey, ou=massey, email=s.wilkinson@massey.ac.nz Date: 2021.04.28 13:45:32 +12'00'
Date:	28/04/2021

(This form should appear at the end of each thesis chapter/section/appendix submitted as a manuscript/ publication or collected as an appendix at the end of the thesis)

DRC 16

MASSEY UNIVERSITY
GRADUATE RESEARCH SCHOOL

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Amarachukwu Nnadozie Nwadike
Name/title of Primary Supervisor:	Professor Suzanne Wilkinson
Name of Research Output and full reference:	
Challenges facing building code compliance in New Zealand	
In which Chapter is the Manuscript /Published work:	Chapter 8
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	90%
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
Literature search, data collection, data analysis and drafted the first manuscript	
For manuscripts intended for publication please indicate target journal:	
Published in International Journal of Construction Management	
Candidate's Signature:	Amarachukwu Nnadozie Nwadike Digitally signed by Amarachukwu Nnadozie Nwadike Date: 2021.04.15 08:35:11 +12'00'
Date:	15/04/2021
Primary Supervisor's Signature:	suzanne Digitally signed by suzanne DN: cn=suzanne, c=NZ, o=massey, ou=massey, email=s.wilkinson@massey.ac.nz Date: 2021.04.28 13:45:58 +12'00'
Date:	28/04/2021

(This form should appear at the end of each thesis chapter/section/appendix submitted as a manuscript/ publication or collected as an appendix at the end of the thesis)

GRS Version 4– January 2019

MASSEY UNIVERSITY
GRADUATE RESEARCH SCHOOL

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Amarachukwu Nnadozie Nwadike
Name/title of Primary Supervisor:	Professor Suzanne Wilkinson
Name of Research Output and full reference:	
Improving resilience through effective building code compliance	
In which Chapter is the Manuscript /Published work:	Chapter 9
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	90%
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
Literature search, data collection, data analysis and drafted the first manuscript	
For manuscripts intended for publication please indicate target journal:	
Published in the proceeding's of 2019 International i-Rec conference	
Candidate's Signature:	Amarachukwu Nnadozie Nwadike — Digitally signed by Amarachukwu Nnadozie Nwadike Date: 2021.04.15 08:39:01 +12'00'
Date:	15/04/2021
Primary Supervisor's Signature:	suzanne — Digitally signed by suzanne DN: cn=suzanne, c=NZ, o=massey, ou=massey, email=s.wilkinson@massey.ac.nz Date: 2021.04.28 13:46:20 +12'00'
Date:	28/04/2021

(This form should appear at the end of each thesis chapter/section/appendix submitted as a manuscript/ publication or collected as an appendix at the end of the thesis)

DRC 16

MASSEY UNIVERSITY
GRADUATE RESEARCH SCHOOL

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Amarachukwu Nnadozie Nwadike
Name/title of Primary Supervisor:	Professor Suzanne Wilkinson
Name of Research Output and full reference:	
Promoting performance -based building code compliance in New Zealand	
In which Chapter is the Manuscript /Published work:	Chapter 10
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	90%
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
Literature search, data collection, data analysis and drafted the first manuscript	
For manuscripts intended for publication please indicate target journal:	
Accepted for publication in Journal of Performance of Constructed Facilities	
Candidate's Signature:	Amarachukwu Nnadozie Nwadike Digitally signed by Amarachukwu Nnadozie Nwadike Date: 2021.04.15 08:42:43 +12'00'
Date:	15/04/2021
Primary Supervisor's Signature:	suzanne Digitally signed by suzanne DN: cn=suzanne, c=NZ, o=massey, ou=massey, email=s.wilkinson@massey.ac.nz Date: 2021.04.28 13:48:45 +12'00'
Date:	28/04/2021

(This form should appear at the end of each thesis chapter/section/appendix submitted as a manuscript/ publication or collected as an appendix at the end of the thesis)

GRS Version 4– January 2019

DRC 16

MASSEY UNIVERSITY
GRADUATE RESEARCH SCHOOL

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Amarachukwu Nnadozie Nwadike
Name/title of Primary Supervisor:	Professor Suzanne Wilkinson
Name of Research Output and full reference:	
Identification of parameters to develop a theoretical framework to improve building code amendment in New Zealand	
In which Chapter is the Manuscript /Published work:	Chapter 11
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	90%
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
Literature search, data collection, data analysis and drafted the first manuscript	
For manuscripts intended for publication please indicate target journal:	
Published in the 54th International Conference of the Architectural Science Associat	
Candidate's Signature:	Amarachukwu Nnadozie Nwadike Digitally signed by Amarachukwu Nnadozie Nwadike Date: 2021.04.15 08:55:54 +12'00'
Date:	15/04/2021
Primary Supervisor's Signature:	suzanne Digitally signed by suzanne DN: cn=suzanne, c=NZ, o=massey, ou=massey, email=s.wilkinson@massey.ac.nz Date: 2021.04.28 13:47:12 +12'00'
Date:	28/04/2021

(This form should appear at the end of each thesis chapter/section/appendix submitted as a manuscript/ publication or collected as an appendix at the end of the thesis)

GRS Version 4– January 2019

DRC 16

MASSEY UNIVERSITY
GRADUATE RESEARCH SCHOOL

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Amarachukwu Nnadozie Nwadike
Name/title of Primary Supervisor:	Professor Suzanne Wilkinson
Name of Research Output and full reference:	
An evidence-based framework for building code improvement in New Zealand	
In which Chapter is the Manuscript /Published work:	Chapter 12
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	90%
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
Literature search, data collection, data analysis and drafted the first manuscript	
For manuscripts intended for publication please indicate target journal:	
Submitted to Engineering, Construction and Architectural Management	
Candidate's Signature:	Amarachukwu Nnadozie Nwadike Digitally signed by Amarachukwu Nnadozie Nwadike Date: 2021.04.15 08:46:19 +12'00'
Date:	15/04/2021
Primary Supervisor's Signature:	suzanne Digitally signed by suzanne DN: cn=suzanne, c=NZ, o=massey, ou=massey, email=s.wilkinson@massey.ac.nz Date: 2021.04.28 13:48:07 +12'00'
Date:	28/04/2021

(This form should appear at the end of each thesis chapter/section/appendix submitted as a manuscript/ publication or collected as an appendix at the end of the thesis)

GRS Version 4– January 2019