Assessing Regulatory Framework Efficacy for Seismic Retrofit Implementation in New Zealand

Temitope Egbelakin[1]

Abstract

Seismic retrofitting of earthquake-prone buildings has been a major challenge in many seismically active countries, including New Zealand. Earthquake losses can be minimised through the formulation and implementation of relevant regulatory frameworks such as policies, building codes and legislation. The recent Christchurch earthquakes have demonstrated the vulnerability of the New Zealand built environment to earthquake disasters, which suggest that existing regulatory frameworks may have been ineffective to reduce the impact of large earthquake disasters.

This paper examines the efficacy of existing regulatory frameworks in mitigating the risk posed by earthquake disasters to the community as whole. The multiple case study approach adopted in this paper, revealed significant barriers posed by the New Zealand Building Act and Territorial Authorities (TA) or local councils earthquake-prone policies, to seismic retrofitting of vulnerable buildings. These barriers include the seismic design philosophy and minimum strengthening requirements of the Building Act, timeframes allowed for strengthening and the lack of mandatory disclosure of seismic risks in TA policies. The research findings offer new insights into the impact of expert-driven regulatory frameworks on earthquake risk mitigation, and suggest a reappraisal of the some of the Act's provisions and the policy implementation approach adopted by various local TA.

Keywords: Efficacy, Seismic Retrofitting, Earthquake-prone Buildings (EPBs), Building Act (2004), Earthquake Policies, Territorial Authorities (TA)

1 Lecturer, School of Engineering and Advanced Technology (SEAT), Massey University, Private Bag 102 904, North Shore City 0745 Auckland, New Zealand; T.Egbelakin@massey.ac.nz

1. Introduction

The severity of past earthquake disasters has demonstrated the vulnerability of various communities, including in New Zealand to disastrous seismic events. Earthquake-related regulations such as policies, building codes and legislation are significant for disaster risk mitigation because property owners are mandated by these legislative frameworks to adopt mitigation measures (Burby and May, 1999). The New Zealand government enacted legislation in the Building Act (2004) and developed a building code, various building standards and policies, with the objective of reducing the level of earthquake vulnerability of the public. However, the recent Christchurch earthquakes caused significant widespread damage to buildings and infrastructure, 185 deaths, various causalities and a US$22 billion financial loss (Vervaeck and Daniell, 2011). Many unreinforced masonry buildings (URM) or parts of buildings collapsed and various modern building structures were critically damaged. 80 percent of the people who died from the earthquake disaster were members of the public, including pedestrians and motorists who were outside the collapsed or damaged buildings (Canterbury Earthquakes Royal Commission (CERC), 2012). This high percentage of fatality demonstrates that unstrengthen earthquake-prone buildings (EPBs) do not solely constitute a risk for the building owner or occupants but the whole community. These devastating impacts suggest that existing earthquake-related regulatory frameworks may be ineffective for ensuring public safety and recovery from a major earthquake event. The subsequent section provides an overview of New Zealand's earthquake mitigation policy and implementation process, to offer insights on seismic retrofitting of EPBs.

2. Seismic Retrofit Implementation in New Zealand

In New Zealand, compliance with earthquake-related regulations is mandatory. The Building Act (2004) recommended a seismic retrofit level of 33% of the code requirement for a new building, referred to as the New Building Standard (NBS), by targeting the most vulnerable buildings. This 33% NBS represents the minimum requirement necessary for ensuring safety in an earthquake event. A building having a structural seismic performance score less than 33% NBS is regarded as a high-risk building, a score greater than 33% NBS indicates a moderate risk, while 67% NBS or more is not considered a significant risk. However, 67% of the NBS was considered as a more suitable minimum seismic retrofit level because the Act's minimum requirement was found inadequate to eliminate the non-ductile failure mechanisms found in EPBs (New Zealand Society for Earthquake Engineering, 2006). Therefore, the New Zealand Society for Earthquake Engineering (NZSEE) considered a score of 67% NBS as a more suitable minimum level (New Zealand Society for Earthquake Engineering, 2006). Likewise, the Act stipulates that an existing building that requires alteration or a change of use must comply with the building code in the same manner as a new building (Sections 112-113). In compliance with the Act's regulations, seismic rehabilitation of EPBs often triggers other building code requirements such as fire performance and disability access. Cost implications due to these triggers often discourage building owners from voluntary seismic mitigation (Egbelakin *et al.*, 2011).

Further, the Act mandates local or territorial authorities (TA) to manage the mitigation of earthquake risks within their jurisdiction by developing and adopting a policy that specifically

addresses seismic risks. The Act allows the TA to determine the seismic strengthening level, policy implementation approach and timelines for strengthening the identified EPBs appropriate to their respective regions (Sections 131-132). Despite the NZSEE's recommendation of a higher seismic standard, 73% of the TA adopted seismic retrofit levels between 34% and ≤67% NBS, while 27% of TA adopted 67% NBS (Department of Building and Housing, 2005). Anecdotal evidence suggests that the retrofit levels adopted by the different jurisdictions relate more to available human and financial resources, political demands and earthquake experience than the region's seismicity. In addition, the TA could choose a passive, an active or a combined active-passive approach towards implementing their earthquake policy. The active approach includes a rigorous identification and detailed assessment of potential EPBs, followed by either retrofitting or demolishing identified EPBs within a time period of three to ten years. In the passive approach, seismic strengthening is only triggered only by an application for a building alteration, change of use and the extension of the building's functional life. A total of 45% of the TA chose the active approach, 32% chose the passive approach and 23% chose the combined active-passive approach (Department of Building and Housing, 2005).

Consequences from recent Christchurch earthquakes since September 2010 to date, which include loss of life, property and infrastructure damage, short and long term financial hardship, and disruption to normal social life within the wider community, suggest that the existing regulatory framework such as some of the provisions of the Building Act (2004) and TA policies, designed for earthquake risk mitigation has been ineffective in satisfactorily mitigating earthquake disaster impacts. This study sought to examine the efficacy of the current regulatory framework related to earthquake risk mitigation, and how it affects seismic retrofit implementation of EPBs in New Zealand. Efficacy of earthquake-related policies and legislation as conceptualised in this study, relates to the extent to which the formulation and implementation of these regulations affect earthquake risk mitigation in New Zealand, specifically the strengthening of EPBs. Assessing the efficacy of earthquake-related regulations has been attributed to risks perception, frequency of seismic retrofitting of EPBs, the community's level of acceptable risks and policy formulation and the implementation approach for treating unacceptable risks (Prater and Lindell, 2000; Comerio, 2004; Burby, 2005; Burby *et al.*, 2006).

3. Research Method

A multiple case study approach as referred to by Yin (2009), was adopted in this study due to the complexity of the research problem and the diversity of the different seismic risk regions in New Zealand. Semi-structured interviews and document analysis were used as the data collection techniques. Interviews allowed the different stakeholders involved in earthquake risk management to describe their experiences in the development and implementation of the relevant regulatory frameworks across different seismic risk regions. The evaluation of relevant regulatory documents highlights some of the constraints placed on the implementation of adequate risk mitigation measures by the existing legislative provisions.

Four cities in New Zealand were chosen as case studies, based on their seismicity, hazard factor, percentage of non-retrofitted and retrofitted EPBs, earthquake probability and likely severity. Similarly, participants were selected through a purposeful sampling procedure based on the research objectives and questions and because it allows the selection of relevant key participants involved in earthquake risk mitigation as the units of analysis (Babbie, 2008). The participants selected include building owners, engineers, architects and managers of governmental organisations that include city councils and territorial authorities (TA). Building owners include both persons who have or have not retrofitted their EPBs and may or have been not involved in recent Christchurch earthquakes. Other participants chosen for the interview have at least a minimum of two years' recent involvement in EPB retrofitting projects. These participants were selected in order to make use of their practical knowledge and experience to obtain information and gain a better qualitative understanding of the importance of the different aspects of seismic retrofit decisions. The use of multiple cases and the participant selection method ensure that data reliability and internal validity are strengthened. Forty-eight interviews were conducted and transcribed. All interview transcriptions were analysed thematically using NVIVO qualitative data analysis software. Both participants and industry experts reviewed the findings for confirmation and comments, to establish data validity.

4. Findings

Research findings from this study established that current regulatory frameworks, such as the Building Act (2004) and the TA earthquake-prone policies, pose barriers to seismic retrofit implementation in New Zealand. Key results are discussed in the following subsections within the context of the research investigation.

4.1 Provisions of Building Act (2004)

The findings in the current study show that certain provisions of the Building Act (2004) discussed below constitute potential impediments to the seismic strengthening of EPBs and for future pre-earthquake disaster mitigation in New Zealand.

4.1.1 Minimum Requirement for Life Safety

The minimum requirement of the Building Act (2004), as revealed in this study, serves as an impediment to seismic retrofitting of EPBs by building owners. The minimum requirement tolerates damage to the primary structure and to other building elements in the event of a major earthquake. It is apparent that the 151 deaths resulting from the collapse of the CTV building are perhaps an outcome from a rare event that was not anticipated by the Act's minimum requirement. In addition, hearings from the Canterbury Earthquakes Royal Commission (CERC) investigations suggest that the current minimum does not match the community's expectation of a building's performance in an earthquake (CERC, 2012). Moreover, the minimum earthquake performance level adopted by the Act and the differing New Zealand Society for Earthquake Engineering's (NZSEE) recommendation of a higher seismic performance level for EPBs, has created confusion and misinterpretation amongst building owners and other retrofit stakeholders regarding what retrofit level provides an

optimal result in terms of seismic strength and rehabilitation cost (Egbelakin *et al.*, 2011). Some building owners were found to have adopted the lowest cost-permissible retrofit level without considering the hazard implication of such a structural performance level (Hopkins, 2005). The recent Christchurch earthquakes resulted in enormous losses to both property owners and the country as a whole, which further demonstrates the implications of the Act's minimum requirement. Although the design of various contemporary buildings within the Christchurch CBD ensured that people could safely vacate them immediately after the earthquake, many buildings were considerably damaged and others needed demolition. Also, the Act's minimum requirement contributes to the TA's lack of commitment to earthquake hazard mitigation, which is evident in the implementation approach adopted in their policies, such as lack of public awareness programs and defined timelines for taking action with vulnerable EPBs. Most TA that adopted less than a 50% NBS are unlikely to have proactive risk-reduction programmes, as evidenced in the adopted policies, with 27% of the TA not specifying timeframes for strengthening identified EPBs, and 31% of the TA having no public awareness programmes to promote mitigation within their jurisdictions (Department of Building and Housing, 2005).

4.1.2 Change of Use Conditions

In compliance with the Act's regulations in sections 112 and 115, seismic rehabilitation of EPBs often triggers other building code requirements, such as fire performance and disability access. While it is reasonable to support the objectives of these sections, the cost implications of these triggers often discourage building owners from retrofitting their EPBs. There is thus a need for further research to investigate whether such requirements are justified in the interest of public safety and in relation to other relevant public policies. Similarly, Section 112 requires that a building that is altered shall comply structurally or seismically to the same extent as before the alteration. However, the categories of additions are not specifically covered. For example, a building with a score of 40% NBS could potentially be altered, provided that the resulting capacity is still not less than 40% NBS. Findings from this study showed that the implementation of Section 112 has significantly increased the proliferation of substandard structures within the community, leading to a growing level of vulnerability to seismic disaster. This is particularly evident in the number of collapses of masonry structures.

4.1.3 Lack of Mandatory Disclosure of Seismic Risks

Currently, none of the regulatory mechanisms relevant to earthquake risk mitigation in New Zealand specifically address whether the disclosure of building seismic risks should be mandatory or not. A lack of mandatory disclosure limits different stakeholders' knowledge and awareness of issues related to seismic risk, especially for participants within the property market. Findings from the qualitative study revealed that most of the stakeholders in the market have little or no knowledge about EPBs, seismic retrofit standards, legal obligations and potential liabilities relating to the changes in the Building Act (2004) and TA earthquake policies. Consequently, an insufficient weighting is attached to retrofit costs in investment and purchase decisions by potential buyers and vendors, due to failure to sufficiently account for the seismic rehabilitation costs necessary to strengthen the building,

which results in underinvestment in earthquake risk mitigation. Findings from this study show that mandatory disclosure of a building's seismic risks in relevant regulatory frameworks and property market transactions is necessary, to improve earthquake risk mitigation in New Zealand. For instance, mandatory risk disclosure would ensure that buyers, insurers and lenders are adequately informed, leading to an informed property market.

4.2 Provisions in Earthquake-Prone Policies (Prepared by the TA)

Some of the provisions of the TA earthquake provisions acting as obstacles to earthquake risk mitigation are discussed in this section.

4.2.1 Policy Implementation Approach

The policy implementation approach adopted by TA has several implications. Some of the TA have good programmes in place to mitigate earthquake hazard and risk, while others have done little, or lack adequate resources to implement mitigation measures. The passive mitigation approach adopted by some of the TA serves as an impediment to earthquake risk mitigation. Likewise, findings from the Christchurch earthquake disasters highlight the ineffectiveness of a TA policy taking a passive implementation approach, and the need to urgently implement consistent policies throughout New Zealand to address the potential threats posed to the community.

4.2.2 Timeframes for Retrofitting EPBs

Timeframes for strengthening EPBs vary widely among TA, ranging from 5-30 years depending on the building type and importance level (DBH, 2005). Most of the TA policies also allow for a possible time extension for strengthening EPBs. In the interim, people still reside and work in these vulnerable buildings and they could be susceptible to risks posed by a future disastrous earthquake. The Christchurch earthquakes provide an example of where longer timeframes impede the adoption of mitigation measures. Effective timeframes for retrofitting EPBs is necessary in TA policies, while considering regional hazard factor, resource availability and effective building life span.

5. Discussion of Findings

Certain provisions of the New Zealand earthquake-related regulatory framework pose difficult challenges for earthquake risk mitigation in New Zealand. Some of these constraints include the seismic design philosophy, minimum requirements of 33% NBS, timeframes, disability access and fire requirements in TA policies. The study findings show that the current approach to seismic design in the New Zealand Building Act (2004) is inadequate to ensure people's safety and economic recovery after earthquake disasters. Generally, most earthquake-related policies and legislation do not usually specify any applicable performance standards, but set out objectives that must be achieved or recommend minimum safety requirements, such as in the New Zealand Building Act. However, the New Zealand Christchurch earthquakes have demonstrated that such minimum requirements are not economically viable and do not meet the community's expectations of retrofitting

buildings only for life safety. Also, financial bail-outs from the Earthquake Commission, central government and private insurance companies are inadequate to cover associated expenses from the disasters. Furthermore, the Act's minimum requirement affects the TA' commitment to earthquake risk mitigation, which in most cases will not lead to consistent, strongly implemented, risk-reduction programmes across the medium-to high-risk jurisdictions. This finding is in line with the outcomes from Comerio (2004) and Prater and Lindell's (2000) research that concluded that the minimum requirements of most building-oriented legislative mechanisms are only intended to ensure public health and safety in an earthquake event, and in most cases would lead to a complete economic loss of the building.

Furthermore, decisions regarding the extent of mitigation programmes to be implemented are left primarily to TA. One outcome of such a model is that some districts have good programmes in place to mitigate earthquake hazards (the active approach such as in Wellington), while other communities have done little or lack adequate resources to implement mitigation measures (the passive approach such as in Lower Hutt and Christchurch). Several statements from the research participants revealed that the model of government in New Zealand indicates that city councils and TA do not receive substantial financial support, if any, from central government for reducing earthquake vulnerability. Evidently, there is a need for central government to provide additional resources to local councils and TA if New Zealand's non-tolerance for EPBs is to be increased.

Mandatory disclosure of seismic risks required by the Building Act (2004) could help improve the seismic rehabilitation of EPBs, as owners or developers would be obligated to disclose their building's seismic risks to prospective buyers or tenants at the point of sale or rent. For instance, the owner of the CTV building that completely collapsed in the February 2011 earthquake was unaware of the building seismic risks at the time of purchase. There is a possibility that if the CTV owner had been made aware of the extent of the building's vulnerability to earthquake risks, the cost of retrofitting could have been factored into the investment decision and retrofitting work carried out. Mandatory disclosure of seismic risks would provide a seal on potential EPBs, while communicating more accurate information to the stakeholders. Besides, some of the anomalies, such as lack of access to building risk information and poor risk communication associated with the building safety evaluation processes after the September 2010 earthquake, which contributed to increased disaster losses in the February 2011 earthquake would have been reduced if seismic risks disclosure had been mandatory.

6. Recommendations

Upon the appraisal of current regulatory frameworks and interview findings in four different cities in New Zealand, specific recommendations are presented in relation to the Building Act (2004) and TA earthquake-prone policies. Firstly, there is a need to review the Act's minimum requirement of 33% NBS for seismic retrofitting of EPBs. It is thus suggested that the earthquake-prone threshold should be increased to 67% NBS, as recommended by the New Zealand Society for Earthquake Engineers (NZSEE) (2006), or adjusted more effectively to accommodate occupancy levels in buildings used for commercial purposes.

Secondly, an appraisal of the policy implementation approach and timeframes adopted by some TA is necessary, to allow TA within low to high-risk zones to adopt an active implementation approach, coupled with proactive public awareness programmes and community engagement in order to improve commitment levels and to achieve consistent earthquake mitigation strategies across their regions. Finally, it is necessary to overlay most of the relevant policies and regulations related to natural hazard management and improved urban planning, such as the Land-use Planning and Resource Management Act (RMA) (1991), Civil Defence Emergency Management Act (2002) and historic preservation and disaster recovery with the seismic strengthening of EPBs, in order to promote earthquake hazard mitigation.

Overall, some of the recent devastating earthquakes, such as in Haiti in 2010, Indonesia in 2004 and also in New Zealand, have demonstrated the ineffectiveness of several earthquake regulatory frameworks devised for reducing disaster impacts. Hence the need to adopt proactive approaches to formulate, adopt and implement an effective mitigation policy. Thus, effective methods for reviewing present policies and regulations are necessary to improve earthquake risk and hazard in seismically active countries.

7. Conclusion

The research findings offer new insights into the impacts of expert-driven regulatory frameworks on earthquake risk mitigation. The Christchurch earthquakes have proven that this approach may not be effective in certain disastrous situations suggesting the need for strategies aimed at adequate pre-disaster mitigation strategies. Hence the need to re-examine the current seismic design philosophy that focuses only on life safety and possibly, the minimum acceptable earthquake-prone hazard level would be adjusted to community expectations of building performance in a seismic event. The findings from this study show that the Building Act and TA earthquake-prone policies would be enhanced by undergoing legislative reforms with regard to matters such as minimum requirements, strengthening targets, implementation approach and timeframes. It is important to acknowledge that seismic risk differs across all parts of New Zealand and such differences should be taken into account when determining the regulatory response for each region. Also, a review and realignment of all regulatory documents is necessary to present a robust framework where New Zealand communities such as Christchurch, can gradually recover after a major earthquake disaster, while planning for pre-disaster mitigation against future earthquakes. The findings suggest some practical changes for policies devised for earthquake risk mitigation, both in New Zealand and other seismically active countries.

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