The 11th Canadian Conference on Earthquake Engineering
Canadian Association for Earthquake Engineering

HOW DO WE ENCOURAGE BUILDING OWNERS TO RETROFIT THEIR BUILDINGS? DEVELOPING AN EVIDENCE BASE OF THE OUTCOMES FOR MARKET LEADERS WHO HAVE RETROFITTED THEIR COMMERCIAL PROPERTIES

Felicity Powell
Dr, Opus Research, Opus International Consultants Ltd., New Zealand
Felicity.Powell@opus.co.nz

Abigail Harding
Dr, Opus Research, Opus International Consultants Ltd., New Zealand
Abigail.Harding@opus.co.nz

Jean Beetham
Ms, Opus Research, Opus International Consultants Ltd., New Zealand
Jean.Beetham@opus.co.nz

Jared Thomas
Dr, Opus Research, Opus International Consultants, New Zealand
Jared.Thomas@opus.co.nz

ABSTRACT: There would be potentially significant human, economic and environmental consequences if a major earthquake was to occur in British Columbia as evidenced by the Christchurch earthquakes during 2010-11. Whilst new buildings in British Columbia are designed to withstand a moderate earthquake without significant structural damage and a major earthquake without collapsing, retrofitting of existing buildings is voluntary unless triggered by building improvements. There are a range of complex factors that influence building owners' decisions to seismically retrofit their buildings, including regulatory framework, financial resources and the perceived benefits arising from the upgrade. Research suggests that owners are influenced by market leaders' behaviour (Alesch et al. 2012), and this paper addresses the knowledge gap of the outcomes of retrofitting that will encourage owners to invest in improving the earthquake performance of buildings. Following the 2010-11 earthquakes, there has been reduced demand for commercial buildings in New Zealand that do not comply with New Building Standard. As a result in Wellington, New Zealand's capital which sits on top of an active geological fault, owners of some commercial buildings have proactively retrofitted their buildings with the upgrade of one building alone reputedly costing NZ$84m (CA$79m). In this new study, evidence was sought from building owners in Wellington of the outcomes of the retrofitting process, e.g. the impacts on building values, tenancies and incomes, as well as changes to the usable commercial floor space due to the engineering solutions. The purpose of this investigation is to provide an evidence base to give more confidence to owners contemplating investing in the retrofit of their property. This knowledge will be relevant to urban areas similarly at risk from earthquake events, such as cities in British Columbia, and will contribute to the discourse on earthquake strengthening.

1. Introduction

1.1. Consequences of major earthquakes

Simulations of the consequences of a large earthquake off the coast of Vancouver Island in the Cascadia subduction zone show that British Columbia could expect potential indirect and direct economic loss from such an event to be about CA$75 billion, of which only about CA$20 billion is currently insured (AIR Worldwide, 2013). Almost 80 per cent of the CA$75 billion estimated cost is likely to be loss of property (AIR Worldwide, 2013). Whilst new buildings in British Columbia are designed to withstand a moderate earthquake without significant structural damage and a major earthquake without collapsing, retrofitting of existing buildings is voluntary unless triggered by building improvements.

The Canterbury earthquake sequence of 2010-2011 was New Zealand's most devastating recent reminder of the huge costs that earthquakes can have. The most damaging shake in this sequence was a shallow magnitude 6.3 earthquake that occurred on 22 February 2011, killing 185 people and causing widespread damage to local buildings and infrastructure. As of March 2015, the Canterbury earthquakes have resulted in the demolition of 1086 commercial buildings, the partial demolition of 158, and the repair of 50 (CERA, 2015), as well as damage to over three quarters of Christchurch's housing stock (Parker & Steenkamp, 2012). The New Zealand Treasury has conservatively estimated the public cost of the Canterbury earthquakes to be NZ$20 billion (CAGNZ, 2014) and insured losses are estimated at an additional NZ$30 billion (Parker & Steenkamp, 2012). Since the Canterbury earthquakes there has been reduced demand for tenancies in New Zealand's commercial buildings considered earthquake prone. A building being designated as earthquake prone has multiple implications for its owners, including lower property values; poor cash flow; and higher insurance premiums (Powell et al 2014).

1.2. New Zealand regulations

New Zealand's current Building Act (2004) classifies buildings that are less than 34% of the New Building Standard (NBS) to be earthquake prone. According to the New Zealand Society for Earthquake Engineering (2006), a structural seismic performance score of less than 34%NBS is considered high risk, a score greater than 33%NBS indicates an earthquake risk building, and a score of 67% or more is considered a low earthquake risk. The Act gives local authorities powers to require building owners to mitigate (strengthen or demolish) buildings[1] that are less than 34%NBS. The legislation also requires local authorities to adopt a policy regarding their approach and priorities for earthquake prone buildings within their jurisdiction.

The territorial authority for New Zealand's capital city, Wellington City Council (WCC), has taken a relatively proactive approach to ensuring the mitigation of the city's earthquake prone buildings ('EPBs'). Wellington's Earthquake Prone Buildings Policy was adopted in 2006 and amended in 2009. Under this Policy, WCC is assessing all of the city's pre-1976 commercial buildings, as well as residential buildings that are more than two storeys high and contain more than three household units. Initially, a desktop review of property and land files is used to identity buildings that require further assessment. WCC then uses the Initial Evaluation Procedure (IEP) developed by the New Zealand Society for Earthquake Engineering to assess the strength of the building to resist earthquakes as a percentage of New Building Standard (NBS). Buildings deemed to be one third or less of NBS are identified as potentially earthquake prone. The council writes to owners of these buildings, who then have 6 months to provide evidence that their building is not EQ prone at their own cost. Failing this, a notice is issued, declaring the building as earthquake prone and requiring it to be strengthened or demolished within a set timeframe. This timeframe is usually between 10 and 20 years depending on the buildings use, importance, age and condition. The notice issued is bright yellow and must be prominently displayed for building users to see. If no action is taken within the allowed timeframe, a bright red notice is issued for display requiring immediate closure of the building.

[1] Including buildings used for residential purposes if the building comprises 2 or more storeys; and contains 3 or more household units.

1.3. Factors influencing mitigation

There are a range of factors that influence building owners to mitigate their earthquake prone buildings of which the regulatory framework is just one element. As well as being influenced by the actions and beliefs of other owners (or in other words the social context), there is evidence pointing to the importance of the personal experiences and beliefs of owners, and their perceptions of earthquake risk. Also important are financial factors which include the building owner's ability to pay and the extent that owners believe that net benefits will be derived if they decide to upgrade (Alesch et al. 2012; Egbelakin et al. 2008).

Although building owners' perceptions that net benefits will result is an important factor in their decision to mitigate their earthquake prone building, there is a dearth of evidence available in New Zealand documenting that it will do so. This means that some building owners, who are considering strengthening, may not have access to the information they need in order to make robust decisions. Additionally, research has shown that owners may be influenced by market leaders' behaviour (Alesch et al. 2012), and thus this paper addresses the knowledge gap of the outcomes of seismic strengthening for market leaders. By establishing such an evidence base in Wellington, New Zealand, other owners may be encouraged to invest in improving the earthquake performance of their buildings. Thus, the aim of this investigation is to begin to build an evidence base that will give more confidence to owners contemplating the investment in strengthening their property.

2. Method

During February and March 2015 we interviewed nine owners of commercial property in the Wellington CBD about a total of eleven buildings to gain insight into their experiences of earthquake strengthening. This investigation is ongoing and so the findings reported here are preliminary, but already strong consensus viewpoints have emerged from the interviews to date, and it is anticipated that these early findings will be indicative of the completed study. In order to explore the influence of the Christchurch earthquakes of 2010-2011 on the decision to increase %NBS, the strengthening of the buildings had to either have begun after 4 September 2010 (the date of the first Canterbury earthquake), or be in the process of being strengthened, have three or more floors, and have at least one office-based commercial tenant. During the semi-structured interviews participants were asked about the factors which influenced them to strengthen their building/s; their experience of strengthening, including provisions they made for their tenants; and the outcomes, including any changes to building value and rental income immediately before and after strengthening.

3. Findings

The interviews revealed a difference in the outcomes arising from upgrades to heritage or character buildings, and those arising from upgrades to more modern buildings. Of the eleven buildings, seven were built during the period 1900-1930 and are considered to be character buildings, and many of these are noted or listed for heritage features by the Wellington City Council or appear on the New Zealand Heritage List under the Heritage New Zealand Puhere Taonga Act 2014. The remaining four buildings were built within the period 1960-1990 and are not considered to have heritage features. Two of the owners interviewed had strengthened both a character and a modern building, and reported different outcomes for each building.

As was previously noted for buildings damaged by the 2007 Gisborne earthquake (Powell et al 2014), earthquake prone buildings provide an opportunity for construction and property development companies to acquire character buildings cheaply, strengthen them using in-house resources or contacts, and increase building value markedly.

3.1. Factors influencing decisions to earthquake strengthen

The interview findings support the extant literature with regard to the wide range of factors influencing owners' decisions to earthquake strengthen their buildings. In particular, the importance of social norms in terms of tenant perception of safety (Alesch et al 2012; Solberg et al 2010; Egbelakin et al 2011; Kohiyama et al 2008; Wolfe et al 2014) and compliance with local government regulations (Alesch et al 2012; Egbelakin et al 2011; Powell et al 2014). Indeed the most commonly cited reasons for upgrading were: (1) tenant demand for strengthened buildings following the Canterbury earthquakes of 2010-2011,

and (for some) the 2013 earthquakes experienced in Wellington; and (2) receipt of a notice from the Wellington City Council (WCC), notifying that the building is potentially earthquake prone.

There was a general perception that the commercial property market in Wellington CBD is characterised by greater supply than demand for office space. The Canterbury earthquakes of 2010-2011 brought building safety to the fore for most tenants, and particularly government departments. Many owners have found that in order to retain tenants or attract new ones, their building needs to have a high NBS rating. Most owners mentioned that despite the Building Act specifying that less than 34% NBS is the threshold for being earthquake prone, government departments will not lease space in a building that is less than 67% NBS, and this sets a precedent in the market place.

Financial factors play a significant role in the decision to strengthen as an owner must be able and willing to prioritise funds for seismic strengthening (Alesch et al 2012; CIR 2013; Egbelakin et al 2014; WEPBCT 2014). Some interview participants, whose strengthening costs were high, mentioned the advantage of owning freehold property and that strengthening would be unaffordable if they had a mortgage on the building.

A number of studies have demonstrated the influence of personal perceptions on a building owner's decision to strengthen (Alesch et al 2012; Egbelakin et al 2011; Fujima & Tatano 2013; Matthews 2011; Powell et al 2010; Solberg et al 2010), including: risk perception; impressions of the costs and benefits associated with strengthening; sense of control over and responsibility for mitigation; and certainty over the efficacy of seismic retrofitting as an effective mitigation measure. For example, some of the building owners sought to strengthen their building as much as possible, whilst others accepted the more affordable of two options, resulting in a lower %NBS rating. There was a general acceptance that all commercial buildings will eventually be strengthened. Some of the owners clearly sought to be market leaders, recognising that "the early movers reap the rewards" in terms of increased rent take per square metre.

3.2. The retrofitting experience

The interview participants emphasised the importance of maintaining good communication with their tenants regarding the upgrades. The nature of the structural engineering solutions determined whether tenants remained in situ for the duration of the retrofit, or relocated elsewhere. Where the strengthening work could be conducted with tenants in situ, good communication meant that tenants were retained. One owner, who took back the management of his building from a property management company, explained that they had lost his tenants through "aggressive rent review behaviour and terrible communication". Unfortunately for that owner, a significant government tenant was lost prior to him taking control of the management of his building.

To avoid paying compensation, owners whose buildings had to be vacated, waited for lease agreements to end before moving tenants out. In one instance, office tenants could remain in situ but a ground floor restaurant businesses had to move out and cease operations for four weeks during ground anchor strengthening. The restaurant received compensation for this short period of closure, and the restaurant owners then took this opportunity to refurbish their premises prior to reopening. Noisy strengthening work was conducted outside office hours. Where tenants remained in situ and strengthening work was conducted in stairwells, dust generation and obstruction of fire exits had to be carefully managed.

When asked if the outcomes achieved though strengthening were what they had anticipated, all of the character building owners agreed, and some commented that their expectations had been exceeded given ensuing tenant demand for their strengthened building. Comments regarding the modern buildings were more mixed, with some owners feeling disappointed that strengthening had not resulted in higher rents. Some of the owners suggested that, government tenants aside, "people are already forgetting" about earthquake prone buildings and that smaller businesses are already willing to trade off lower cost office space for a lower %NBS rating.

Participants were also asked what advice they would give other building owners considering strengthening their building. Some commented that they would not want all low NBS buildings in the CBD to be strengthened as it would weaken their own position in the market. Others emphasised the importance of the peer review process for engineering solutions, as peer review gave them more

confidence and in some instances resulted in a cheaper solution. Importance was placed on financial planning, and good communication with tenants was also reiterated. The benefit of selecting engineers with good track record in the earthquake strengthening of commercial buildings was also evident as they have a good grasp of relevant engineering solutions and local government processes. Similarly, the construction and property development companies that dealt with character buildings suggested that for older buildings, owners needed to have a good grasp of engineering solutions themselves and that such buildings were "best left to the experts".

3.3. Outcomes of earthquake strengthening

Participants were asked about the outcomes of the earthquake strengthening process, including the impacts on building values, tenancies and incomes (Table 1). A building's %NBS rating is but one variable influencing building value and the willingness of tenants to pay for office space. For example, where tenants were moved out of the building in order to strengthen, owners took the opportunity to do new fit-outs, which in turn increased building value, their appeal to prospective tenants, and the rents that tenants would be willing to pay. Similarly, some locations are in higher demand than others, which also influences building value and rent take. All other things being equal, the value of an untenanted building is less than a tenanted building, so where we asked owners about the change in building valuation immediately pre- and post- strengthening some of the larger changes in value can be partially attributed to this. Of course, without earthquake strengthening, these buildings would be unlikely to attract tenants. Unfortunately, it is not possible to view the influence of earthquake strengthening in isolation to these other factors.

Building owners make trade-offs between the costs of engineering solutions to strengthen their buildings and the resulting %NBS. The cost to upgrade character buildings is higher than modern buildings, with a median cost of CA$4,240,000 (range: CA$203-$8,573 per m^2) as opposed to a median cost of CA$377,000 (range: CA$41-$659 per m^2) for the more modern buildings. This is not surprising, as the engineering solutions for older buildings tend to be more expensive because of the additional costs associated with preserving character and heritage features, for example removing and replacing tiles and interior plaster detailing.

The greater cost to strengthen is somewhat offset by higher market demand for character buildings in Wellington, as demonstrated by increased building value and greater rent take per square metre post-strengthening. On average, earthquake strengthening increased the value of the character buildings by 282% (range: 17-1054%), whilst modern buildings only increased 23% in value on average (range: -23-72%). Similarly, rental values per square metre increased an average of 72% (range: 50-150%) and 48% (0-103%) for character and modern buildings respectively. The owners of modern buildings shared the sentiment that strengthening is necessary to retain or attract tenants, but is associated with a lower rental premium than for character buildings, and the costs of strengthening were thus considered "dead money" or necessary maintenance.

Table 1. Summary of outcomes from earthquake strengthening

Outcome factor	Character buildings (built 1900-1930) (n=7)	Modern buildings (built 1960-1990) (n=4)
% NBS pre-strengthening	6-42%	6-59%
% NBS post-strengthening	70-100%	75-100%
Cost to strengthen* (range)	CA$565,000-$9,420,000	CA$104,000-$1,700,000
Cost to strengthen* (median)	CA$4,240,000	CA$377,000
Cost to strengthen (range per m2)	CA$203-$8,573	CA$41-$659
Change in Value** (range)	17-1054%	23-72%
Change in value** (range)	282%	23%
Change in rental income per m^2*** (range)	50-150%	0-103%
Change in rental income per m^2*** (average)	72%	48%

*Excluding refurbishment costs. **Estimated where strengthening unfinished or official valuation incomplete. ***For office space, on average as can vary per floor

4. Findings discussion

The aim of this investigation was to begin to build an evidence base that may give more confidence to New Zealand building owners contemplating investing in the seismic retrofit of their property. This investigation is ongoing and so the findings reported here are preliminary, but already strong consensus viewpoints have emerged from the small sample of interviews to date, and it is anticipated that these early findings will be indicative of the completed study.

The preliminary findings suggest that the main factors to have influenced the sample of Wellington owners' to strengthen their building/s were increased tenant demand for higher %NBS following the Canterbury earthquake sequence, and being required to do so by the local council if their building was notified as earthquake prone. All of the building owners interviewed had strengthened to at least 70%NBS in order to meet the demands of the marketplace, the standards of which appear to be well above the regulatory minimum of 34%NBS. Some of the building owners discussed that being in a strong financial position enabled them to undertake work on their building, and that their ability to take such action would have been limited if their finances were otherwise. In general, the owners felt that the strengthening of

Wellington's commercial building stock was inevitable, and some mentioned that being proactive allowed them to lead the market and thus reap greater financial gains.

Dealing appropriately with tenants was important for a successful strengthening project for the building owners we interviewed. While the nature of the structural engineering solutions determined whether tenants remained in situ for the duration of the retrofit, or relocated elsewhere, good communication and fair treatment of tenants was seen as leading to better tenant retention across the board. Some of the study participants emphasised the importance of considering the costs and benefits of strengthening to a range of %NBS targets, as well as commissioning an independent peer-review, as these may save money and increase confidence in the engineering solutions used. Additionally, it was seen as beneficial to select an engineer with a strong track record in seismic strengthening as well as one with good industry and local authority relationships.

It is difficult to view the influence of earthquake strengthening on building values and rental income in isolation, since other factors such as location, refurbishment, and occupancy will also influence these outcomes. That being said, this study found that while character buildings in this sample tended to be more expensive to strengthen than modern buildings, they also benefited from a greater uplift in value and rental income after the work was complete. However, it is likely that earthquake prone character buildings significantly dropped in value in the past five years so some of this value increase is likely to be 'recovered lost value'. Despite that, it does appear that in Wellington some tenants prefer character office space, and as there is a shortage of such spaces which are seismically strengthened, for this type of building this leads to a rent premium. Owners of modern buildings were more likely to consider seismic strengthening to be akin to maintenance, necessary to attract and retain tenants but not associated with significantly increased rental intake.

4.1. Application elsewhere

Further research is needed to understand the relevance of these findings to other places, particularly places outside of New Zealand. The Wellington context may well be relatively unique, given its proactive regulation of earthquake prone buildings as well as strong market demand for buildings of a high seismic standard. This means the drivers and outcomes of seismic strengthening may not be similar for building owners in other places at this time. However, these findings demonstrate that proactive regulation and raised tenant awareness of earthquake prone building risks can create a marketplace for stronger, safer buildings. From such a context, building owners could perhaps expect financial benefits from undertaking seismic strengthening especially where demand exceeds supply.

However, the evidence collected in this investigation will contribute to the discourse on earthquake strengthening, and has begun to reveal the diversity and nuance of experiences and outcomes for owners who seismically strengthen their buildings, and these need to be better understood. The authors of the present study are considering doing research on the outcomes of strengthening in New Zealand's provincial towns and cities where market demand and regulation are not significant drivers to do so.

5. Acknowledgements

We would like to thank the research participants who gave their time to be interviewed. This research is part of the *Acceptable seismic risk in commercial buildings* research programme funded by New Zealand Ministry of Business, Innovation and Employment.

6. References

AIR Worldwide. 2013. *Study of Impact and the Insurance and Economic Cost of a Major Earthquake in British Columbia and Ontario/Québec*. Study commissioned by the Insurance Bureau of Canada. October 2013.

Alesch, D., Arendt, L., & Petak, W. (2012). *Natural Hazard Mitigation Policy: Implementation, Organizational Choice, and Contextual Dynamics*. Springer.

Canterbury Earthquake Recovery Authority (CERA). 2015. "Demolitions list". Accessed 2 March 2015 from http://cera.govt.nz/demolitions/listAlesch, D., Arendt, L., & Petak, W. 2012. *Natural Hazard Mitigation Policy: Implementation, Organizational Choice, and Contextual Dynamics.* Springer.

Colliers International Research (CIR). 2013. *Tenant earthquake risk assessment (TERA) survey*. Auckland: New Zealand.

Controller and Auditor-General New Zealand (CAGNZ) Tumuaki o te Mana Arotake. (2014). "Part 3: Public sector funding for the recovery in Canterbury". Accessed 21 July 2014 from http://www.oag.govt.nz/2012/canterbury/part3.htm

Egbelakin, T., & Wilkinson, S. 2008. Factors affecting motivation for improved seismic retrofit implementation. Paper presented at the *Australian Earthquake Engineering Conference* (AEES).

Egbelakin, T., Wilkinson, S., Potangaroa, R., & Ingham, J. 2011. Enhancing seismic risk mitigation decisions: a motivational approach. *Construction Management and Economics*, 29, 1003-1016.

Egbelakin, T., Wilkinson, S., & Ingham, J. 2014. Economic impediments to successful seismic retrofitting decisions. *Structural Survey*, 32(5), 449-466.

Fujima, T., & Tatano, H. 2013. Promoting seismic retrofit implementation through 'nudge': Using warranty as a driver. *Risk Analysis*, 33(10), 1858-1883.

Kohiyama, M., Kiremidjian, A.S., Meguro, K., & Yoshimura Ohara, M. 2008. Incentives and disincentives analysis for improving policy for seismic risk management of homeowners in Japan. *Natural Hazards Review*, 9, 170-178.

Matthews, P. 2011. *Death zone*. The Press, 10 April. Retrieved 17 July 2014 from http://www.stuff.co.nz/the-press/news/christchurch-earthquake-2011/4867859/Death-Zone

New Zealand Society for Earthquake Engineering. 2006. Assessment and improvement of the structural performance of buildings in earthquakes: Prioritisation Initial Evaluation Detailed Assessment Improvement Measures. *Recommendations of a NZSEE Study Group on Earthquake Risk Buildings*. June 2006 (Including Corrigenda Nºs 1 & 2).

Parker, M., & Steenkamp, D. 2012. "The economic impact of the Canterbury earthquakes". Reserve Bank of New Zealand: Reserve Bank Bulletin. Accessed 2 March 2015 from http://www.rbnz.govt.nz/research_and_publications/reserve_bank_bulletin/2012/2012sep75_3parkersteenkamp.pdf

Powell, F., Beetham, J., Harding, A. 2014. Post-event business recovery: Varying recovery trajectories and perverse outcomes. Paper presented at the *Australian and New Zealand Disaster and Emergency Management Conference*. Surfers Paradise, Gold Coast (QLD), 5-7 May

Powell, F., & Harding, A. 2010. Business recovery and the rebuilding of commercial property. In '*Shaken Up'*, the Published proceedings of a workshop on recovery following the Gisborne earthquake, 7 December 2009. Opus International Consultants Ltd: Lower Hutt.

Solberg, C., Rossetto, T., & Joffe, H. 2010. The social psychology of seismic hazard adjustment: re-evaluating the international literature. *Natural Hazards and Earth System Sciences*, 10, 1663-1677.

Wanganui Earthquake-Prone Buildings Community Taskforce (WEPBCT). 2014. *Report to Wanganui District Council*.

Wolfe, A.K., Malone, E.L., Heerwagen, J., & Dion, J. 2014. *Behavioural Change and Building Performance: Strategies for Significant, Persistent, and Measurable Institutional Change*. Report prepared for the U.S. Department of Energy under Contract DE-AC05-76RL01830. Pacific Northwest National Laboratory, Richland, WA.