FACTORS AFFECTING MOTIVATION FOR IMPROVED SEISMIC RETROFIT IMPLEMENTATION

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ABSTRACT

Earthquake is one of world's greatest disasters, claiming many lives and causing extensive damage to lives, properties and the economy. Seismic retrofitting of existing vulnerable buildings is one of the means of reducing hazards during an earthquake, thus it is an important activity in any earthquake-prone region. The field of hazards mitigation, most especially seismic retrofits faces a series of issues and challenges relating to implementation. Some of these challenges are lack of knowledge of available systems, cost of strengthening, regulatory constraints, perception of earthquake occurrence and risks. Although technologies have been developed to reduce or eliminate the risks associated with earthquake prone buildings (EPBs), retrofitting to maximum permissible strength is not always undertaken because many factors interact to influence retrofit decisions. The New Zealand Building Act (2004) also seeks to reduce the level of earthquake risk to the communities over time. However the implementations of retrofitting techniques has experienced a slow progress and in some cases were never carried out by building owners. It is possible that building owners are not always motivated to strengthen their earthquake prone buildings. This research aims to identify how owners of EPBs can be motivated to adopt high seismic standards during seismic rehabilitation.

This study identified various factors affecting owners of EPBs motivation for improved seismic retrofits implementation in New Zealand. Through semi-structured interviews, factors identified were categorized into three major factors namely economic and social factors and regulatory requirements. Suggestions on the importance and influence of these factors were evaluated and discussed.

KEY WORDS
Building owners, Motivation, Earthquake prone buildings (EPBs), Seismic retrofitting, decision-making

1.0 Introduction

Strengthening of EPBs has been a major challenge confronting earthquake prone regions over the years. Significant amount of technical solutions, resources and legislative means have been provided to ensure appropriate implementation of seismic retrofit measures. Technical solutions ranging from strengthening of parts of the structure to seismic isolation and active control has been developed. Similarly, the New Zealand Building Act (2004) enacted seismic retrofit regulations for all identified EPBs. However, the application of adequate retrofitting techniques has not been undertaken. Hopkins (2005) noted that buildings owners usually adopt cheaper cost options without considering the necessary level of strengthening. Johnston et al. (2006) and Stevens and Wheeler (2008) also acknowledged the prevalence of low response from owners to retrofit their EPBs.

The paper is part of a research study on enhancing pathways to improved seismic retrofit implementation, funded by the Foundation for Research, Science and Technology. The overall research aim is to examine strategies that could motivate owners of EPBs to voluntarily retrofit beyond what is legally required and also to develop a quantitative tool that will demonstrate the financial, social and environmental implications of such a decision. The research focused only on the commercial building sector. The importance of this sector can be valued and demonstrated in terms

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of high percentage of older buildings (which are usually earthquake prone due to age and decaying of construction material) used for commercial purposes in New Zealand. For instance, Wellington has about 52% EPB (Stevens and Wheeler, 2008). Also, the Building Act (2004) in its definition of EPBs captures buildings mainly used for commercial purposes (S. 122 (1) and (2)). Location is another important concern, most EPBs are usually concentrated within the central business districts. In addition, economic benefits that would accrue from seismic loss estimation, in terms of loss of lives and property, business continuity and preservation of heritage buildings make this sector worthy of consideration.

This paper examined various factors influencing owner's motivation for improved seismic retrofit performance. Possible solutions that will mitigate their influence on owner's motivation were evaluated. The significance of these factors identified in relation to seismic retrofit implementation was also discussed.

2.0 Seismic Retrofitting in New Zealand

New Zealand is located within a region that is highly susceptible to earthquake. Seismic retrofit is one of the means of reducing hazards during an earthquake with a fundamental objective of reducing injury or loss of life, property and ensuring business continuity in an event of an earthquake. Another major advantage of seismic strengthening is the preservation of older buildings, which are usually caught within the retrofit upgrade legislation. Economic benefits accruing from seismic strengthening have also been demonstrated (Nuti and Vanzi, 2003). Langston et al, (2007) highlighted the significance of strengthening older buildings over demolition and construction of new ones. Similarly, Stevens and Wheeler (2008) emphasized that retaining the quality of existing buildings plays a key role in ensuring sustainability of the construction industry and our communities as a whole.

In New Zealand, compliance to earthquake building standards is obligatory. The Building Act (2004) seeks to reduce the level of earthquake risks to the public over time, recommending minimum level of seismic retrofit (one-third of the strength of a new building). The Act further delegates the territorial authorities (TA) to determine the level of seismic retrofit level applicable to its region. A number of TA's adopt the two-third of code requirement, while others adopt one-third of code requirement. However, the minimum requirement stipulated by the Building Act has been found not to completely eliminate the danger in EPBs (DBH, 2004). They argued that 33% of the new building standard (one-third of the strength of a new building) does not totally eliminate the non-ductile failure mechanism and critical structural weaknesses in EPBs. Although the actual level to which a building is upgraded will depend on the nature and particular circumstances of the building as well as the effect of the remedial work on the performance of the building, NZSEE considers 67% of the new building standard as an appropriate level to reduce or remove the danger, and therefore recommends it. This reduces the risk from about twenty to around three times that of a new building.

Local adoption and implementation of high seismic standard in seismic mitigation policies is rather difficult politically as it places additional economic or regulatory burdens on a particular group of people such as building owners, land developers and property investors. It is also difficult because the benefits associated with seismic strengthening are uncertain and only occur in the future (at the time of an earthquake). Building owners are usually faced with the dilemma of what levels of seismic retrofit to adopt with their limited budget when making decision about seismic rehabilitation. Hopkins (2005) revealed that building owners were noted to adopt a lower level of seismic retrofit, regardless of the recommendations from consulting engineers. He also mentioned that the implementation of seismic retrofit of EPBs has experienced substantial slow progress. Stevens and Wheeler (2008) added that seismic retrofit in some cases are not carried out. This has resulted into loss of many valuable historic buildings. Moreover, EPBs is a major hazard to the public and community as a whole. Tierney (2004) explained that seismic retrofit implementation is one of the most important challenges facing the hazards mitigation. An important area in hazard reduction that has been identified by the Earthquake Engineering Research Institute (EERI) and New Zealand Historic Places

Trust (NZHPT) is to focus on how to motivate building owners to voluntarily improve the seismic performance of their building. This research intends to fill this gap.

This study applied the principles of motivation to understand the underlying factors influencing retrofit decisions. Why people take certain decisions and why they act the way they do has probably been a prominent question ever since people were able to reflect upon their own behaviour and actions. Motivation is one of the significant factors influencing decision for any action or behaviour at any particular time. Hickson and Khemka (2001) explained that "within the context of decision-making, motivation can affect whether a person chooses to engage in a decision making process at all, to what extent as well as their selection of a goal and of their means for attaining that goal". The relevance of motivation in the decision making process has been demonstrated in literature. Blustein and Flum (1999) emphasized the importance of applying motivational perspective to understanding how individuals develop interest and make decision. Ryan and Deci (2000) developed a comprehensive motivational framework, which has demonstrated ubiquitous influence of motivation across behaviour. They suggested that the degree to which an individual make decisions is a manifestation of their underlying motivational orientation. It is thus necessary to understand various motivational factors influencing seismic retrofit decisions particularly on the level of seismic standard adopted. This will help to identify factors that can help motivate owners of EPBs to adopt high seismic standard.

3.0 Research Method

The objectives of the research are to; (1) understand how building owners make decisions about the level of seismic standard to adopt (2) examine why some building owners make decisions to adopt higher seismic standard despite the stance of the law (3) propose ways to enhance voluntary adoption of higher seismic standard and (4) demonstrate the economic, social and environmental implications of this decision. Only the first two objectives will be covered in this paper.

Triangulation is employed as a research strategy in this study. Triangulation adopts two or more research methods to investigate a given phenomenon. It provides multiple perspectives on a research problem, in-depth understanding of the phenomenon being studied and ensuring validity of the data collected. This research adopts two research techniques namely, qualitative and quantitative methods. The researcher's choice of research strategy takes into account the nature of the research problem. Tookey (1998) explained that the nature of a particular problem will further dictate its means of solution. Given the multi-disciplinary nature of the research topic, it is appropriate to adopt a research strategy that will capture the holistic and contextual description, revealing the varied dimensions of the phenomenon under investigation. Also a lack of comprehensive theoretical perspective and empirical research on the topic, preclude the immediate implementation of a single method approach. A sequential approach would be followed which had the qualitative findings leading into the design of the quantitative phase.

An exploratory qualitative phase aimed at identifying the motivational factors influencing building owners' decisions for improved seismic retrofit implementation would be reported in this paper. Case studies were used to examine these factors and interview was selected as data collection technique. Interviews were guided by a set of semi structured open-ended questions. 20 interviews have been conducted to date with different stakeholders identified in seismic retrofit implementation in order to gain a better understanding of the research topic within the New Zealand context. The stakeholders identified for the research are; building owners, professional and consultants, managers of insurance, financial and governmental organizations that has been involved in the decision-making process of seismic rehabilitation of EPBs. The idea was to make use of their practical knowledge and experience in obtaining information and gain a better qualitative understanding of the importance and influence of different factors on seismic retrofit implementation. The ongoing research will continue with interviews within the seismic performance sector within different regions in New Zealand.

4.0 Factors influencing the decision to adopt high seismic standards

The findings reported in this section are based on two sources of empirical data. The first source is a review of literature on motivation and the institutional context governing the seismic retrofit implementation in New Zealand. The second source is the on-going semi-structured interviews conducted within the study. The findings indicated that stakeholders involved in seismic retrofit implementation recognise the need and importance to motivate and incentivise owners of EPBs, for seismic retrofit to make meaningful impacts in hazard mitigation. The findings presented below are categorized under three major headings namely, economic factors, social factors and regulatory requirement.

4.1 Economic factors

4.1.1 Cost associated with seismic retrofit

Cost associated with seismic retrofit is a major economic driving force affecting seismic retrofit implementation. Findings from both interviews and literature reveal that it is a critical factor influencing the decision to improve seismic performance of EPBs. One of the interview participants from one of the city councils mentioned that,

> "Cost of improving seismic performance of a building is enormous and usually work is not visible until completion"

Cost involved in seismic retrofit can vary widely making it difficult to adequately estimate the total amount of cost that might be involved. This variation is dependent on a number of factors such as location and type of structure, characteristics of individual buildings, rehabilitation scheme, level of performance desired and other work(s) in the building code triggered by this decision. Both direct costs (construction cost, non-seismic related construction cost and non-construction cost) and indirect costs (costs due to business disruption and revenues), associated with seismic retrofit further complicate the whole process of cost estimation in seismic retrofit projects.

90% of building owners interviewed are usually faced with the burden of cost and the question, **"is this investment worth it?"** They pointed out that one of motivators to invest in retrofit is the likelihood of cost recovery (through increased rents or at the time of sale) in an acceptable period of time. Only 10% of the building owners on the other hand, believed that though the investment is exorbitant at the time of retrofitting, it help to minimise future business disruption due to future changes in regulation and cost savings from future seismic rehabilitation. One of the participants suggested that a crucial strategy for managing the cost of improved seismic performance is to roll cost into larger upgrade i.e. build as much as possible buildings into the ongoing facility management program. Also, team work during the design of rehabilitation project can help to reduce cost as all stakeholders discuss and evaluate cost cutting measures as a team. Substantial financial aid to owners of heritage EPBs was also added as a significant motivator for improved seismic retrofit implementation.

4.1.2 Insurance

Insurance is a vital consideration in managing earthquake risks and has significant implication for mitigation investment decisions. Earthquake insurance policies in New Zealand generally cover a portion of shake damage to a structure from an earthquake. The building owner may also need to spend money for rehabilitation in an event of an earthquake for damages not covered under the policy. Insights from interviews indicated that buildings retrofitted well beyond minimum requirement should be eligible for premium discounts. EERI (1998) suggested that the price of insurance premium should reflect risk and take into account mitigation actions on the building if it reduces the expected insurance losses on the structure. 92% of the interviewees viewed discounts in insurance premiums as a key component of any hazard mitigation program aimed at improved seismic performance of EPBs. It was also suggested that requirement for higher seismic performance by insurance companies from the insurer would aid seismic mitigation measures. However, one of the participants from the insurance industry viewed this as rather difficult to implement as a result of the dynamic and competitive nature of the industry unless required by regulation.

It should be clearly stated here that while insurance is potentially a major component in the total risk management plan for an EPB, it is not in itself a technique to improve seismic performance of a building. In fact, the availability of insurance may act as an impediment to taking action to improve a building's performance. An example is moral hazard[3] which results in underinvestment in mitigation plans. This was clearly apparent with some building owners interviewed, as they view insurance as a means of dealing with earthquake risks rather than acting safely.

4.1.3 Financial Incentives

Availability of incentives has been identified as a strong motivator for decision making. Incentive is any factor (financial or non-financial) that provides a motive for a particular course of action. Both forms of incentive were considered to be important in motivating high seismic retrofit standard. The interview sessions revealed a strong preference for both financial and non-financial incentives for heritage buildings, while only non-financial incentives were accorded to non-heritage buildings. Reasons were related to benefits associated with preservation and high cost of protecting fabrics of heritage buildings. The financial incentives identified are: grants, property tax rebates, fee waivers, low interest rate loans, tax deductibility, subsidies and tax credits. Non-financial incentives will be discussed under the social factors section.

In New Zealand, some of the identified incentive programs are made available to only a few categories of heritage buildings. A general consensus was noted that the funds provided by the New Zealand Historic Place Trust to only few heritage buildings are too small to make any meaningful impact. One of the participants suggested that if financial incentives are insufficient, other elements of non- financial incentive should be added to the mitigation program, so that when combined will adequately motivate owners. It is important to implement additional financial incentive programs to allow successful seismic implementation. However, in order to make incentive programs efficient and cost effective it is important to appraise the program's ability to meet its objectives.

4.1.4 Market Conditions

Using the market place to create value for seismic safety has been suggested as a strong motivator for improving the seismic performance of buildings in literature (May et al. 1998 and Hopkins, 2005). This research employed this perspective to investigate how market values can drive motivation for higher seismic standards in New Zealand. 80% of building owners are burdened with the questions of, "how strong is the market for the building, can the revenues from the building pay off the debt for retrofit"?, before taking decisions on the level of seismic standard to adopt. This concern is common among building owners who lease or sell the buildings after rehabilitation. Results show that the following factors are possible ways of driving market values for seismic retrofit in New Zealand;

- introduction of a standardised building rating system such as the NZSEE grading system
- more knowledgeable tenants demanding improved seismic standard
- creating third party services for seismic rehabilitation assessment to aid information disclosure to prospective buyers and tenants

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[3] Moral hazard is an insurance term that refers to the phenomena that having insurance diminishes the insured's motivation to act safely

- real estate market boom- increasing value for investment returns on properties
- lenders and insurers obligatory requirement of improved building performance to ensure that earthquake risks are equitably distributed in the market place
- minimal business interruption desired by building owners and tenants

Market-based incentives can offer prevailing reasons for different stakeholders and the public at large to retain, care, invest, and act responsibly to rehabilitate EPBs. There is a probability that if adequate strategies considering some of these factors could be developed or nurtured, the market place might end up taking care of many EPBs within the communities. It is important to note that these above named factors concern various stakeholders involved in seismic retrofit decision-making process. It further suggest how the insurance industry, financial institutions, building owners, tenants, professionals in building and real estate communities can work together to foster seismic rehabilitation with or without governmental participation.

4.2 Social factors

4.2.1 Perception of earthquake occurrence and risks

Findings to date reveal that perception of earthquake occurrence and risks has a great influence on motivation for improved seismic performance. The study found that public awareness, city councils mitigation approaches, uncertainties in earthquake occurrence and past experiences influence people's perception of earthquake risks. These factors tend to be mutually interdependent and in turn influence the kind of mitigation decision people adopt. The study found that 87% of interviewees with earlier experience of earthquake tend to support high seismic performance standard. Most of the respondents within this group are concerned for their safety and business disruption. For instance, one building owner explained,

> "Earthquake occurrence is real to me now and I think my safety and
> that of others is much more important than any other thing."

While those with no earlier experience of earthquake risk were found to possess a nonchalant attitude towards mitigation, though they are generally aware of the risks. Mitigation approach by city councils was also dominated by the perception of earthquake risk. High risk regions with possible occurrence of earthquakes adopt active mitigation programms while regions with less risk adopt passive approaches. This greatly influences the extent to which the public generally becomes aware of risks and as a result affect their decision. Education and awareness programs provided by some of the high risk regions have greatly influenced many owners on the type of risks they are exposed to and consequently their decision to adopt improved seismic standards. However, at the time of writing, the extent to which education and awareness programs influence the insurance and financial industry has not been determined.

These findings agree with Slovic and Weber (2002), and Jaeger's et al., (2002) study on risk perception. They emphasised that perception of risks play an important role in the decisions people make. They submitted that disparities in risk perception lie at the heart of disagreements about the best course of action between various stakeholders involved in mitigation plans and members of the general public. It is recommended that stakeholders involved in seismic retrofit decision-making have good understanding of the risks that are been faced and completely understand the implications of their decisions.

4.2.2 Trust and Beliefs

Trust and belief in seismic retrofit techniques and the associated professionals has been identified as one of drivers for adopting improved seismic retrofit. Hopkins et al. (2006) showed that trust and belief is one of the major factors driving decision-making in seismic retrofit. They concluded that building owners need to have belief in retrofitting solutions and trust in designers, consultants, approval authorities and builders to make the implementation effective. Insights from the interviews show that both factors are highly inter-related; owner's beliefs in professionals will influence their levels of trust in the retrofit solutions. One of interviewees responded saying,

> "I do not really believe in these engineers that we have here, so I waited until I could get a good one in Wellington to help strengthen my building. For instance, have you seen that new building just around the corner? It was supposed to be of higher seismic standard, but partially came down during the last earthquake? See, these engineers don't know anything"

To make adequate retrofit a reality, efforts should also focus on these fundamental aspects. Professionals and regulatory authorities should be required to pay more attention to the designs they recommend and approve. Owners should also be advised on the possible outcome of the retrofit solution they have chosen in the event of an earthquake.

4.2.3 Values and Rewards

Values and rewards in seismic retrofit implementation differ across individuals. Maloney (1986) and Porter and Lawler (1968) emphasised that motivation of an individual largely depends on the need, values and rewards associated with the accomplishment of the task. The interviews revealed that 89% of owners are motivated by the values and rewards that they can get from seismic retrofit implementation. The values and rewards identified include; increased rental value, public recognition in the form of award, monetary and non-monetary reward and self-esteem. These values and rewards identified can be used as a form of non-financial incentives to motivate the adoption of high seismic standards.

Monetary or nonmonetary rewards have been demonstrated to increase the probability of the repetition of desired behaviour (Skinner and Frederic, 1965). The use of monetary incentives to enhance better behaviour is the most common way to reward and motivate people. Many people have also now realised that non-monetary rewards (appreciation, recognition) are valuable motivators. The recognition of individuals and groups with desired behaviour has also been established (Fischer and Nunn, 1992) as a strong motivator for desired repetitive behaviour. Findings from the study revealed that the introduction of awards for best retrofitted EPB and star rating would help improve the adoption of high seismic standards. Adopting some of these rewards in seismic retrofit implementation programs will increase the value and expectations of various stakeholders.

4.2.4 Benefits of seismic retrofit

There are several benefits of improving the seismic performance of a building such as life and property safety, loss reduction, quick business recovery and societal loss reduction. While some decisions about managing the risk for a particular building solely rely on weighing potential loss (physical damage) against potential cost of the improved performance, a number of owners and decision makers were found to factor in some important intangible benefits. Benefits such as protecting lives, business continuity and maintaining competitive position are common among private organisations. Among public orgnisations, the benefits include protecting lives, health and welfare, preservation of heritage buildings, reducing the need for displacement and demolition as well as the ability to provide uninterrupted services.

Another system of assessing benefit is the unacceptability of the possibility of losing equipments, production capacity (such as a computer component company) or certain buildings (such as hospitals or fire stations) in the event of earthquake. Consequently the benefits that will accrue in the future may be more substantial than the cost incurred now. This greatly motivates the adoption of high seismic standard. The study also found that observable benefit is one of the strongest motivator peculiar to 97% of the interviewees. For instance, from the last recent earthquake in Gisborne, the author found that owners of EPBs feel that the benefits of improved seismic performance outweighed the costs. It is therefore imperative to demonstrate the expected economic, social and environmental benefits associated with seismic retrofit during decision-making.

4.3 Regulatory Requirement

Regulatory requirements involving seismic retrofit can act as important incentives or impediments to improving seismic performance of EPBs. It is a significant feature in the context of the decision-making to improve seismic performance. The New Zealand building code for example, has provisions that trigger seismic upgrade of existing buildings whenever substantial alterations, major repairs, change of occupancy, or use is required. The seismic provisions of the current building code must be adopted. This can be seen as a positive influence. In contrast, the decision to improve the seismic performance of a building often triggers other requirement particularly compliance with disability access, fire requirement and hazardous materials. Meeting all the triggered code requirements at times might be difficult to achieve based on the structure and certain characteristics of the building. The associated cost can also become unacceptably high, thereby discouraging building owners.

This research reveals that regulatory requirement can be a major constraint while some regulatory relief such as reduced permit fees, fee waivers, tax reductions, rateable values taking into consideration of seismic strengthening etc can be an advantage in seismic retrofit implementation. One of the participants mentioned that 20% of the building rehabilitation cost was spent only for disability access. Russell and Jaffee (1996) also explained that most building owners cited regulatory requirements as one of the impediments to taking action. It is important for governmental regulators to adopt some form of regulatory relief that can help reduce this burden on building owners. However, a careful appraisal of such efforts should be carried out in order not to jeopardise the interest of the public and the community as a whole.

5.0 Significance of Findings

The underlying factors influencing retrofit decisions have been revealed in this study. How building owners make retrofit decision about the level of seismic retrofit to adopt has been demonstrated in this research. Decisions are made primarily on regulatory requirements, cost of strengthening, trust and belief in seismic solutions and the related professionals. Most owners of EPBs sought "safe haven" by retrofitting to about 40% of the building standard (a little above the minimum requirement) in order to compile with the law, while some just simply trusted and accepted their engineer's recommendation, others choose the lowest cost options available to them.

Similarly, this research has demonstrated why building owners make decisions to adopt high seismic standards. Decision to adopt high seismic standard are made based on building owners' motivational orientation and it differs across building owners. Market conditions, earthquake occurrence and risks, future cost savings, availability of financial incentives and regulatory relief are strong motivational factors for building owners to adopt high seismic standards. Values and benefits as associated with high seismic standards were also noted to contribute to high motivation.

The identification of various factors influencing motivation for improved seismic retrofit implementation provide crucial "motivational" input in the design and implementation of hazard mitigation programs. Neglecting these motivationally linked factors may create serious risk as it may be difficult to evaluate the level changes in behaviour and attitude that may be induced by incentives. Consequently, it is necessary to consider the motivational nature of incentives, as lack of knowledge on human motivation may limit the understanding and the effects of incentives, thereby making little or no impacts on hazard mitigation efforts.

6.0 Conclusion

Various factors affecting motivation for improved seismic retrofit of EPBs have been presented in this paper. The major factors identified as influencing motivation for improved seismic performance have been grouped under three categories; economic social and regulatory requirements. Firstly, economic factors include cost of seismic rehabilitation, high insurance premiums, financial incentives and market conditions. Majority of the economic factors invariably would either reduce or increase the cost associated with seismic strengthening. Secondly, the social factors identified are perception of earthquake occurrence and risks, trust and beliefs, values and rewards and benefits of seismic retrofit and lastly regulatory requirements involving seismic retrofit implementation.

The findings suggest that while cost and other related economic factors were believed to have been the only major motivator for improved seismic performance in EPBs, the significance of the two other categories also call for attention. It is also important to understand the distinction between these factors and accordingly cater to their effect during the formulation and revision of policies and design of incentives programs. It is hoped that findings presented in this paper will provoke the different stakeholders, researchers and governmental organisation examining seismic retrofit implementation to treat the adoption of improved technical solutions in hazard mitigation as an issue that can be financial socially and politically negotiated.

The future research will further seek to examine the comprehensive assessment of these factors and their roles and importance in decision-making. This is crucial for the subsequent development of any quantitative model that would serve to establish the economic, social and environmental benefits associated with strengthening beyond minimum code requirements.

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