Information Provision and Communication Strategies for Improving Earthquake Risk Mitigation

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Abstract

The severity and economic implication of the recent Canterbury earthquake disaster in New Zealand and continual reticence of building owners living in earthquake-prone buildings showed that property owners are unwillingness to adopt appropriate earthquake risk mitigation measures. This unwillingness suggests that the earthquake mitigation information provided and communication strategies may have been ineffective for making informed mitigation decision. This study examines the relevance of mitigation information provided and the efficacy of existing and emerging communication strategies for making informed risk mitigation decisions. Data were collected using structured questionnaire from property owners of earthquake-prone buildings. This study identifies seventeen significant strategies, clustered under five categories that may contribute to successful earthquake risk mitigation in New Zealand, specifically for retrofitting earthquake-prone buildings. These strategies include the provision of a unified safety assessment information system, mandatory disclosure of seismic risks and the use of novel approaches such as the social networks, mass media, reiterating past earthquake experiences and public recognition of pro-social mitigation behaviour are paramount. Subsequent review and adoption of these strategies could communicate relevant risk information to all stakeholders involved in earthquake risk mitigation, leading to informed risk mitigation decisions.

Keywords: Earthquake-prone buildings (EPBs), Earthquake risk information, Communication strategies, Mitigation decisions

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1. Introduction

Given the recency and severity of the Canterbury earthquakes swarm in New Zealand since 2011, it is not surprising that seismic hazard and disaster is a frequent topic of conversation among the residents, visitors and media. According to Paton and Johnston (2006), frequent thought, discussion and information receipt about earthquake risks is necessary to propagate the awareness of earthquake risk and assist people to make decisions and work towards the adoption and implementation of appropriate risk mitigation measures. Likewise, the availability of relevant earthquake mitigation information, and the means of communicating and disseminating this information to property owners and the public, are significant parameters that can be used to influence desired decisions regarding risk mitigation (Keeney and Winterfeldt, 1986; MacGregor *et al.*, 2008). However, the continual reticence of building owners living in earthquake-prone buildings (EPBs) to retrofit their EPBs suggest that the present risk mitigation information provided and communication strategies are ineffective for enhancing their decision to improve the level of earthquake risk mitigation in New Zealand. The aim of this study is to investigate relevance of risk mitigation information provided, and the effectiveness of existing and emerging communication strategies necessary to enable informed risk mitigation decision regarding seismic rehabilitation of EPBs.

2. Earthquake Risk Information and Communication Strategies

The provision and communication of adequate risk information is an important parameter when attempting to explain how people make seismic risk mitigation decision because of its primary objective of providing and sharing information about the hazard, associated risks and appropriate mitigation measures (Paton, 2006). According to Neuwirth *et al.* (2000), the provision of appropriate information about seismic risks and the efficacy of mitigation measures should produce greater rates of willingness to adopt protective measures. Likewise, Lindell and Perry (2004) explained that in order to yield desired outcome of improved earthquake risk mitigation, an effective natural hazard information provision and communication program should consider good quality of information provided, credibility of information source, means of communication and the management of the whole communication process.

Earthquake risk information can be communicated through both informal and formal channels. Several traditional approaches such as printed brochures, warning letters to property owners, regulatory requirements and penalties have been used in communicating earthquake risk information to the public. According to Whitney *et al.* (2004), conventional methods of risk communication have little influence because they are perceived to lack novelty, validity or relevance. Mileti and Fitzpatrick (1993) suggested that conventional methods of risk communication can be improved by using an alternative novel approaches for communicating earthquake hazard and risk information. In addition, previous research suggested that in order to generate an effective response from risk communication, the distribution of earthquake preparedness information and materials should include a mix of passive and proactive approaches that utilizes both traditional and emerging information technologies such as reiterating past earthquake experiences within community networks,

using mass media and policy entrepreneurs (Bourque *et al.*, 2010; Egbelakin *et al.*, 2011). Moreover, Paton and Johnston (2006) established that an effective risk communication strategies implemented at the community level will likely led to risk personalisation that allows people to deliberate mitigation plans at the community level and this could lead to preparedness and are likely will enhance seismic risk mitigation decisions. However, Lindell and Perry (2004) found that providing and communicating earthquake risk information does not necessarily motivate people to adopt mitigation measures or divert significant efforts into assessing alternative sources or channels for providing risk information. A significant portion of people preferred to remain ignorant about natural hazards such as earthquake because of a failure to personalise the risk, when poor quality of information is provided, perceived credibility of information source, inadequate dissemination strategy or perceived incapability of making use of additional information (Lion *et al.*, 2002).

Perception of credibility to the source of risk information impacts seismic mitigation decisions (Whitney *et al.*, 2004). Earthquake risk information is provided through various sources, which include governmental authorities, media, peers, friends and family, and are judged in terms of their perceived credibility. The credibility of information source comprised of three primary characteristics; expertise, trustworthiness and past reliability in communicating risk information (Perry and Lindell, 1990). Generally, governmental authorities such as local council or government officials and earthquake risk mitigation professionals such as engineers are commonly considered as credible source of information (Mileti and Sorensen, 1988). Mass media and peer contacts have also been identified as sources that are perceived as credible. However, there is a growing awareness about the impacts of the media in communicating hazards information to the public (Scanlon, 2009). Likewise, inconsistency and disparity in risk information provided by the different risk provision sources reduce its credibility and quality of information and the ability of the information to assist in making constructive mitigation decisions (Poortinga and Pidgeon, 2004; Paton, 2007). In addition, existing research studies have suggested that using adequate risk communication approaches with sound dissemination plan to enhance earthquake risk mitigation and implementation has an advantage of simultaneously improving people's perception regarding earthquake probability and severity, fatalistic mind sets and improving trust in the efficacy of seismic design techniques for reducing earthquake risks (Paton, 2007; Smith, 2009).

A key issue in earthquake risk mitigation concerns information acceptance, whether existing information provided is relevant and have been effectively communicated to generate enough concern and response that could enhance the likelihood of adopting mitigation measures. Despite the volume of research work on risk information provision and communication, there remains a lack of clarity regarding the provision of relevant information for making informed decision, and the efficacy of communication strategies for increasing the likelihood of property owners' adoption of adequate mitigation measures. An investigation of novel risk information provision and communication approaches such as using the social media, public recognition, reiterating past survival stories in social events, regulatory requirements and risk communication process management, is necessary highlight the efficacy of such novel methods for improving earthquake risk mitigation.

3. Research Method

This paper reports a part of the research findings of a recently completed study undertaken to examine the relevance of earthquake mitigation information provided to property owners, and the effectiveness of existing and emerging communication approaches necessary to facilitate informed risk mitigation regarding seismic rehabilitation of EPBs. Twenty-five factors that include type of risk mitigation information provided, sources of information and communication strategies were operationalised from literature and preliminary interviews, and their level of usage and effectiveness for making appropriate risk mitigation decision was tested in fieldwork.

A cross-sectional survey research design was adopted and data were collected using an online questionnaire through Survey-monkey portal. The population frame of this study comprised identified owners of EPBs. The sampling frame comprised owners of EPBs identified after the enactment of the Building Act (2004) and who may have and have not retrofitted their EPBs, but have all been notified by their local TAs of their buildings vulnerability to seismic disasters since 2004. The sampling frame indicates that responses used in the research were directly from the study population. Respondents were mainly asked to indicate on a five-point likert scale, the extent to which mitigation information provided as well as existing and emerging communication strategies could or have helped them to make informed risk mitigation decisions. The questionnaire was pre-tested in a pilot survey before an industry wide survey was conducted. The data were entered into SPSS for analysis. Preliminary analysis conducted such as analysis of missing data and normality test was conducted for data clean-up and to fulfil normality and goodness of fit criteria. Kolmogorov-Smirnov test conducted showed that all responses to the variables are normally distribute with a p-value larger than 0.05. The mean of each variable was compared by conducting an independent sample t-test (Compeau and Higgins, 1995). A test value of 3 was used to test whether the means were significantly different from a mid-point of 3 on a Likert rating scale of 1 to 5. T-tests were used to identify effective information provision and communication strategies that are likely to enhance building owners' decision to retrofit their EPBs. A relevant mitigation information, source of information and communication strategy is considered significant when $p<0.05$. Industry experts reviewed the findings for confirmation and comments to establish data validity.

4. Sample Characteristics

A total of 510 online questionnaires were administered and 208 surveys were completed representing a response rate of 40.8%. This response rate compares favourably with other studies in earthquake risk management (Ronan *et al.*, 2001; Lindell *et al.*, 2009). The analysis of the questionnaire provides a summary of the respondents' profile and EPBs projects undertaken. A summary of respondents' demographic information and a selected retrofitted EPB projects were provided in Tables 1 and 2. Information summarised in Tables 1 and 2 suggest that most of the respondents are familiar with seismic risk mitigation decision and retrofitting of EPBs projects. For instance, the respondents' geographical distribution indicates that people residing in low to moderate and high risk earthquake prone regions are well represented in the study. Also, the majority of the projects reported are

located in high-risk regions (89%). In addition, most of the buildings have recently been retrofitted; 52% were retrofitted less than a year ago and 32% were strengthened between the last two and four years. Hence, the respondents profile and selected retrofitted EPBs projects indicate that they are well experienced on the subject matter and in a position to provide reliable information.

Table 1 Respondents Profile

Category	Frequency	%
Respondent's Location		
Auckland	46	23
Wellington	63	31.5
Christchurch	51	25.5
Gisborne/Napier	19	9.5
Others: Low seismic risk region	16	8
Others: High seismic risk regions	5	2.5
Personal Experience of an Earthquake Event		
No	*63*	*31*
Yes	*137*	*69*
Years of experience in EPB Projects		
<5years	53	26.5
6-10years	21	10.5
11 - 15 Years	19	9.5
16 - 20 Years	12	6
21 - 25 Years	23	11.5
> 25 Years	26	13
Not Applicable	46	23

Table 2 Characteristics of EPB projects handled by respondents

Category	Frequency	%
Building location		
Auckland	13	6.5
Wellington	60	30
Christchurch	52	26
Gisborne/Napier	38	19
Others: low seismic risk region	9	4.5
Others: high seismic risk regions	28	14
Period of construction		
Prior to 1935	96	48
After 1935	44	22
After 1964	42	21
After 1976	15	7.5
After 1992	2	1
Prior to 2004	1	0.5
Building's historic registration category		
Heritage Category I	75	37.5
Heritage Category II	82	41
Unsure	43	21.5
Building category		
Residential	8	4
Commercial	104	52
Mixed-use (commercial and residential)	51	25.5
Institutional (churches, schools)	28	14
Others	9	4.5
Most recent retrofit period		
<1 year	104	52.0
2-4 years	65	32

5-7 years	18	9.0
8–9 years	6	3.0
>10 years	7	4
Seismic retrofit performance level		
<10% NBS	6	3
10-33%	35	18
33-67%	48	24
67-100% NBS	55	27
Unsure	44	22

5. Significant Earthquake Risk Information Provision and Communication Strategies

Twenty-five factors that include quality of information provided, communication strategies and source of information were investigated, and seventeen were found significant for improving seismic retrofit decision and implementation of EPBs. These seventeen factors were further clustered under five categories (see Table 3). Significant earthquake risk information provision and communication strategies within the context of the research investigation are discussed below.

Table 3: Significant Earthquake Risk Information and Communication Strategies

Code	Information Provision and Communication Strategies	Mean	t- value	p-value
Source of Earthquake Risk Information (SRI)				
SRI1	An earthquake risk mitigation Exhibition	2.01	2.76	0.08
SRI2	Earthquake risk Professionals (e.g. engineer/architect)	2.85	1.94	0.07
SRI3	Government officials	3.96	3.36	0.05*
SRI4	Family/friends	4.13	3.12	0.00*
SRI5	Mass Media	3.73	2.51	0.02*
SRI6	Lessons learnt from past earthquake experience	4.88	3.18	0.01*
Quality of Earthquake Risk Information Provided (QIP)				
QIP1	Provision of sufficient information about exposure to earthquake risks and efficacy of mitigation measures	3.01	4.28	0.04*
QIP2	Providing information about benefits of retrofitting	4.88	3.32	0.00*
QIP3	Information provided about earthquake risks and mitigation was easy to understand	3.09	4.88	0.20
QIP4	Provision of a unified safety assessment information system	4.21	4.28	0.00*
Using Regulatory Requirements (RR) for dissemination information				
RR1	Implementing a building grading system	2.79	3.12	0.00
RR2	Mandatory disclosure of building seismic risks	3.91	3.60	0.00*
RR3	Comprisal of seismic risks in property valuation assessments	4.36	2.11	0.04*
RR4	Sanctions for owners not non-retrofitted EPBs	1.88	1.02	0.08
Risk Information Dissemination and Communication strategies (RIDC)				
RIDC1	Building Earthquake risk notice received from TA	2.03	2.51	0.61
RIDC2	Using social media to disseminate risk information	4.24	3.41	0.00*
RIDC3	Intensify the use of mass media	3.58	2.09	0.04*

Code	Information Provision and Communication Strategies	Mean	t- value	p-value
RIDC4	Reiterating of past earthquake stories and coping strategies	4.01	3.15	0.00*
RIDC5	Introduction of public recognition award	3.79	2.74	0.01*
Risk Communication Management				
RC1	Form of communication	2.88	2.23	0.10
RC2	Frequency of communication	2.39	6.55	0.06
RC3	Quality of communication among stakeholders	4.79	2.74	0.01*
RC4	Quality of communication system	3.61	4.28	0.00*
RC5	Working relationship with owner	4.89	3.55	0.00*
RC6	Extent of managing public image and public relations	3.79	2.74	0.01*

*Significant information provision and communication strategies at 0.05 sig. level

5.1 Source of Earthquake Risk Information

Source of earthquake risk information could significantly influence property owners' decision to adopt appropriate risk mitigation measures. The results presented in Table 3 show four significant sources of earthquake information that would likely influence how property owners make risk mitigation decisions regarding their EPBs. These significant information sources are government officials (SRI3), family/friends, (SRI4), mass media (SRI5) and lessons learnt from past earthquake experience (SRI6). Earthquake risk information provided by government officials, media, family/friends and from lessons learn from past earthquake experience are perceived as accurate and would likely enhance building owners' decision to adopt appropriate risk mitigation measures. This finding shows that respondents assigned a higher level of credibility to these information sources implying a higher level of trust to these information sources. However, it can be plausibly concluded that a lower level of credibility and trust is assigned to risk information provided by earthquake risk professionals such as engineers, which could negatively influence seismic mitigation decisions. This low level of credibility may be related to building failures in the Christchurch earthquake disaster where newer buildings supposedly designed to new seismic standards were significantly damaged. According to Lindell and Perry (2004), when low credibility is accorded to hazard related professionals, people tend to search for other sources of risk mitigation information such as the media and family/friends. Thus, justifying the significance of the positive mean rating accorded to the media and family/friends in this study. Furthermore, the results show that the respondents accepted information gained through past earthquake experience without questioning, but does not intend to use any of this information in near future. The acceptance of information gained from past experience and coping strategies implied that human cognitive and decision-making processes relies more on association and familiarity with earthquake risk issues. This finding emphasise that personal experience produces more vivid memories and testable facts of the disaster event than a pallid description of events or mitigation approaches.

5.2 Quality of Earthquake Risk Information Provided

Analysis of the quantitative data presented in Table 3 provides ample evidence on the relative impact of good quality of risk information on mitigation decisions. Three main factors necessary to maintain a high level of quality earthquake risk information are; providing sufficient information about exposure to earthquake risks and the efficacy of mitigation measures (QIP1); providing information about benefits of retrofitting EPBs (QIP2); and the provision of a unified earthquake safety assessment information system (QIP4). The provision of sufficient information about a hazard and potential mitigation measures increases a person's knowledge about the hazard, influence the level of risk perception and could consequently influence the adoption of adequate mitigation measures. In addition, the results indicate that the when potential benefits are adequately communicated, it may lead to a higher level of perceived benefits ascribed to an expected decision outcome, consequently, leading to higher chances of adopting risk mitigation decision. Therefore, property owners risk mitigation decisions can be promoted by highlighting potential benefits from adopting mitigation measures such increased safety, property value and possible future savings in a future earthquake event. This finding assert several postulations of expectancy-valence models that emphasised the role of perceived benefits in decision-making (Steel and Konig, 2006). Moreover, the findings from the study suggest a lack of provision for a unified earthquake risk information system, where all the stakeholders intending to use the information can access it. The availability of information system would provide quick access to earthquake risk information to property owners and all the stakeholders.

5.3 Regulatory Requirements

Two key potential regulatory requirements emerged in this study with the possibility to effectively facilitate property owners' decision to adopt adequate mitigation measures. These requirements are mandatory disclosure of building seismic risks (RR2) and comprisal of seismic risks in property valuation assessments (RR3) (see Table 3). Mandatory disclosure of seismic risks and comprisal of seismic risks in property valuation assessments through relevant policies would ensure that owners and property retailers are obligated to disclose a building's seismic risk to prospective buyers or tenants at the point of sale or letting in the property market. The increased awareness may lead to informed market stakeholders and consequent improvement of the EPBs market value assessments. Thus, an increase in the property value would provide financial returns at the point of sale or letting to the owners of retrofitted EPBs, leading to the augmentation of their perceived benefits from implementing seismic mitigation measures as discussed in Section 5.2. It is not surprising that the implementation of a building grading system and sanctions for owners of non-retrofitted EPBs as shown by the results is insignificant. The purpose of such a grading system is to "raise awareness of seismic risk issues and ultimately induce voluntary adoption of beyond-code seismic performance standard imposed by the legislation. The grading system involves displaying a letter grade such as A to E on an EPB to denote the level of earthquake risk in the building. Some of the interviewees during the preliminary interview mentioned that the implementation of such a grading system is likely to result in a series of judicial cases where the grading and sanctions will be disputed.

5.4 Risk Information Dissemination and Communication Strategies

Findings from this study show that existing earthquake risk communication strategy has mainly by formal issuance of notice letters by the TAs to property owners and the distribution of brochures, which have been ineffective enhancing owners' decisions to retrofitting their EPBs. To successfully disseminate and communicate earthquake risk information, the findings reveal four novel approaches using social networks such as twitter and face book (RIDC2), mass media (RIDC3), reiterating past earthquake experiences and coping strategies in social functions (RIDC4) and public recognition of pro-social mitigation behaviour (RIDC5). This research finding demonstrated that these novel four approaches can be used to increase the salience of seismic risk by providing accurate information to the public regarding the extent of risk exposure and severity of a potential disaster. These approaches would also help to shape people's perception of risk and personalisation, disaster severity and improve their knowledge regarding the efficacy of risk mitigation measures. In addition, sufficient and appropriate media attention oriented towards effective mitigation measures rather than sensationalism is necessary to provide a favourable atmosphere for adopting earthquake mitigation measures.

5.5 Risk Communication Management

Results presented in Table 3 shows six significant communication management practices that could potentially increase the likelihood of building owners adoption of risk mitigation measures. Presently, only a formal written communication method such as letter and email represent the predominant means of communication. An exploration of regular face-face meeting (RC1 and RC2) may lead to joint ability among the stakeholders to collectively identify risks, proffer mitigation strategies and plan implementation actions necessary to adequately mitigate the risks. Other risk communication management strategies include high quality of communication among stakeholders in terms of communications planning and process monitoring (RC3), exploring quick dissemination of information and novel approaches (RC4) discussed in Section 5.4, and the establishment of appropriate method to generate, collect, disseminate, storage EPB risk information (RC5 and RC6). Effective earthquake risk communication process management would reduce some of the anomalies, such as lack of access to building risk information and poor risk communication process associated with the building safety evaluation process after the September 2010 earthquake in New Zealand. These anomalies contributed to the increased disaster losses in the February 2011 earthquake. Also, it is important for professionals such as engineers and government officials to strive and maintain a good public image and public relations with building owners by paying greater attention to seismic designs recommended approved by regulatory authorities. Having good public relations is particularly important in order to earn building owners' trust regarding the efficacy of earthquake risk-reduction measures.

6. Discussion of Results

Significant earthquake risk information and communication strategies for improving seismic retrofit implementation in New Zealand have been revealed in this study. Effective risk information and communication strategies are needed to explain to those at risk regarding

how seismic hazard and risks are identified, assessed and managed effectively within limited resources. The research findings shows that improving the quality of earthquake risk information provided to building owners, effective risk communication management, using regulatory requirements such as mandatory disclosure of seismic risks and most importantly the provision of a unified safety assessment information system would significantly improve the likelihood of property owners' adoption of earthquake mitigation measures. These findings support PADM's postulation regarding the use of a momentous risk-communication approach for improving earthquake risk mitigation.

The provision of a unified safety assessment information system that offers risk information about the vulnerability of potential EPBs to earthquake mitigation stakeholders and the public is central to bridging some of the related problems associated with seismic risk mitigation decisions. The information system would help other relevant professional groups and property market stakeholders to access any building's seismic risk data and enable all stakeholders to work toward a consensus mitigation strategy. This availability of this information system will help them become aware of commonly encountered issues and imperatives regarding earthquake risks. Evidence from the recent Christchurch earthquakes provides further justification regarding the impact of haphazard information system on the overall earthquake vulnerability in New Zealand. Lack of access to adequate risk information about the performance of buildings in the earthquakes could significantly slow down the reconstruction process in Christchurch. In the CERA report (Canterbury Earthquakes Royal Commission (CERC), 2012). The provision of a safety information system could yield widely accessible and valuable information about the condition of potential EPBs across the country.

7. Conclusion

The objective of this study is to examine the relevance of mitigation information provided, and the effectiveness of existing and emerging communication strategies necessary to facilitate informed risk mitigation decisions. A survey research method adopted revealed seventeen significant strategies for improving seismic retrofit implementation of EPBs. These strategies are categorised in the following five groups; (i) source of information, (ii) quality of information provided (iii) regulatory requirements, (iv) information dissemination and communication strategies, and (v) risk communication process management. The research findings may help stakeholders involved in earthquake hazard and risk management to be better prepared towards the provision relevant information and communication strategies aimed at increasing the likelihood of EPBs owners' adoption of risk mitigation measures. A better understanding of relevant earthquake mitigation information and communication strategies may help the stakeholders to review the existing approaches and could facilitate appropriate channelling of limited resources into the right areas to achieve desired risk mitigation decision.

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