Earthquake risk reduction actions for New Zealand

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ABSTRACT: This paper discusses what we already do and what extra should be done to reduce earthquake risk in New Zealand. Some of these needed actions have been learned from the consequences, good as well as bad, of earthquakes that have occurred both in New Zealand and in other parts of the world. A list of 23 weaknesses is identified in New Zealand's systems of earthquake risk reduction. Remedial actions to overcome these weaknesses in a balanced way involve at least nine parties. Nine of the weaknesses have five or more parties who could or should take some remedial action over them. Engineers have technical actions to address 15 of the weaknesses, while earthquake-related professions have an advocacy role to play in all of them. The potential exists for reducing earthquake losses by about an order of magnitude, i.e. worth billions of dollars and thousands of casualties in future earthquakes.

1 INTRODUCTION

The recent earthquake disasters in Turkey, Taiwan and India have their lessons for other parts of the world, including New Zealand. The big simple observation about Turkey, Taiwan and India is that the terrible losses of life, injuries, losses of jobs, and so on, could so easily have been greatly reduced if even modest use had been made of the more readily implementable knowledge that has been available in the past few decades. These countries sadly had gaps in their systems which could easily have been made good.

2 NEW ZEALAND'S EARTHQUAKE RISK REDUCTION STRENGTHS

New Zealand has sufficient strengths in the arena of earthquake risk reduction to provide a firm and clear basis for improvements to be made in the future. When the main strengths are labelled generically, we here identify 16 of them (there may be more). These strengths are listed in Table 1, where they have been divided into three groups of five or six each, designated as:

Obviously all societies and their systems of dealing with perils are imperfect. Hence even the countries most advanced in earthquake resistance science and technology have gaps in their defences, such as was illustrated in the severe effects of the earthquake that hit the Kobe area of Japan in 1995, and the many buildings which were defective in the Northridge earthquake which hit California in 1994. So we in New Zealand need to examine what gaps exist in our mainly good systems of earthquake risk reduction, and fill the gaps in appropriate ways. There are such gaps in New Zealand. So there are some unnecessary disasters waiting to happen. We will discuss them below.

First, however, we should recognise the good parts of our system, the strengths that we have to build on in order to reduce earthquake risk to people, property and prosperity in our country.

˜ People attributes

˜ Control of the built environment

˜ Societal attributes

People attributes comprise all the main skills required, i.e. research, design, construction, enforcement, planning and management. Many of our people are highly regarded internationally, and have strong international links.

Control of the built environment is assisted by having good design regulations for new buildings, bridges and dams, and some existing property. In addition, reasonable supplies are available of good earthquake resistant construction materials.

Societal attributes in part, comprise reasonable levels of poverty, corruption and financial resources, despite New Zealand not being a rich country. In addition, modern and effective systems of government, education, information technology and communications are operative, and we are fortunate to have what is one of the world's highest levels of take-up of earthquake insurance cover.

3 NEW ZEALAND'S EARTHQUAKE RISK REDUCTION WEAKNESSES

We now turn our attention to the weaknesses in our efforts to reduce earthquake risk. Perhaps surprisingly, over a score of weaknesses have been identified here in a preliminary list of weaknesses of a wide range of types. The weaknesses have been initially divided into two main categories, named *strategic* and *tactical* as listed in Tables 2(a) and 2(b), respectively. This division in some cases is somewhat arbitrary, but it helps in comprehending the considerable detail implied by the abbreviated descriptions given to the tabulated weaknesses.

Consider the 11 *strategic* weaknesses listed in Table 2(a). The first of these is clearly strategic, noting that New Zealand has no national strategy for managed progressive reduction of earthquake risk. We need monitored goals of target risk reductions in a series of (say) five-year plans, with priorities assigned at both a national and a local level.

As well as listing weaknesses, Tables 2(a) and 2(b) attempt to list all parties who contribute to remedying each of the weaknesses. The first of these is *Advocacy* by earthquake professionals (engineers, geologists, seismologists, architects, economists, planners, risk managers and others), and one is *Funding* (rather than people). The remaining nine entities, ranging from engineers to central government, illustrate the complexity of the workings of modern society, which by fragmentation constitutes a considerable difficulty (i.e. a weakness) as listed in item A3. As given in Table 2(a), Central Government (G), government departments (g), local government (L) and planners (P), all are needed to address this problem, in addition to the advocacy role of earthquake professionals.

Item A10, over-design in New Zealand's lowest seismic hazard zones results from the historical excessive conservatism of design loadings for northern regions of the North Island, a situation which should be resolved in the current revision of the loadings standard. This is listed as a weakness in order to illustrate the need to spend our limited national financial resources wisely, and emphasise the need for national priorities for risk reduction as discussed above for Item A1.

Let us now turn to the 12 *tactical* weaknesses, listed in Table 2(b), which generally involves more technical detail than the *strategic* weaknesses of Table 2(a). This is illustrated by the fact that in the *Actions by whom* lists, Engineers (E) appear in 11 items of Table 2(b) and only four of Table 2(a). As indicated by Items B1-B4, many components of the built environment are inadequately regulated for earthquake risk purposes. The lack of mandatory regulations for earthquake protection of most built or manufactured items other than buildings is a historical situation (common world-wide) which strongly merits rectification in the interests of earthquake risk reduction. The case of stored goods (stock) in shops, and industrial storage areas. Item B3, is a curious and alarming example. Consider the way that goods are stacked in some shops, notably some supermakets and similar national retail chains. Lethally heavy goods are stacked high overhead in the most dangerous fashion to anyone below. The fact that loose goods or contents of buildings fall to the floor in moderate or strong shaking is common knowledge.

These situations appear to be a breach of the law regarding the safety of the shop employees, and it is surprising and disappointing that the practice has not been stamped out. The deaths and injuries of workers and public alike will be on the slate of the owners and the government, if this situation is not eliminated before the next damaging earthquake.

In the more seismic parts of the country two types of older buildings, of unreinforced masonry (URM) and some concrete buildings (Item B4), pose a serious threat. While many brick buildings have been demolished or strengthened in some parts of the country, the process is somewhat erratic. Even in Wellington where the City Council has been a leader in this field since about 1980, many old unreinforced brick buildings are still in use, death traps to occupants and passers-by. A particularly puzzling case is that of an old Harbour Board shed until recently leased to a shopkeeper. Why has it been left unstrengthened for so long? We might also ask why long-vacated brick buildings should not be demolished forthwith? They pose a great threat to passers-by. Examples of these still exist in Wellington.

The older concrete buildings that are at risk of serious earthquake damage, (Item B4), comprise mainly pre-1976 multi-storey buildings, which have beam and column frames rather than structural walls. In the past several years much work has been done by the NZSEE and the BIA [1, 2] on studying the problems posed by such buildings, and their proposed regulations for assessing and strengthening them were submitted to the Government late in 1998. The issue of what to do about these buildings is rightly contentious as the costs of strengthening will be considerable in many cases.

4 DUTY OF CARE

An important aspect of Tables 2(a) and 2(b) is the influence of *duty of care* on who could be involved in remedial actions. Duty of care is the common law responsibility of a person or body to do something, such as warning others about a situation that they know to be dangerous, even if they are not involved, or if there is no statutory requirement. For example building on an active fault (Item B6) is known by most people to be dangerous, so that in addition to geologists, those who could act on this danger to people and property include engineers, architects, insurers, planners, government departments, local government and the owner of the building.

As the duty of care is surprisingly pervasive, Tables 2(a) and 2(b) should be widely distributed to all concerned.

5 EARTHQUAKE RISK REDUCTION POTENTIAL

The potential for earthquake risk reduction for buildings and equipment is illustrated by Figure 1. Here are plotted the mean damage ratios, D_{rm}, over a range of intensities from Modified Mercalli V (MM5) to MM10, as found for New Zealand buildings and equipment in various earthquakes [e.g. 3,4]. It is seen that the lower bound D_{rm} is about one thirtieth of the upper bound value over the range of damaging intensities MM7-MM10. This suggests that there is the potential for about an order of magnitude reduction in earthquake losses, if the whole built environment were to be converted to the lower bound of vulnerability. This would save billions of dollars as well as many hundreds of casualties in a Wellington fault earthquake.

6 WARRANTS OF FITNESS

In the absence of legal compulsion to retrofit buildings or other property, the concept of a warrant of fitness with a range of grades of fitness has some merit. The range of grades proposed by the NZSEE [2], A, B, and C which pass the test, and D and E which don't, become public knowledge as they would be displayed at the entrance to each building. This would allow prospective tenants, employees, or others who might enter the building, or prospective buyers of the building, to decide what level of risk they are prepared to accept, and puts pressure on the owner to retrofit the building if it is grade D or E.

A related problem is that of risk-enhancing changes that are made to a structure after its initial construction. For example cutting large holes in structural walls, or filling in movement gaps on seismically isolated structures (including bridges). Periodic (quinquennial, say) reviews of the warrant of fitness would capture such problems, but is the compliance cost-justified?

7 CONCLUSIONS

1. Over twenty weaknesses are identified in New Zealand's systems for earthquake risk reduction, some of which are matters of broad policy and others very specific. Perhaps the most fundamental is to develop and operate a national strategy for earthquake risk reduction with time.
2. Actions required to remedy the weaknesses involve more than 10 parties, ranging from earthquake professions to government and property owners. A preliminary check list of who should do what has been presented. Such a check list should be circulated to all parties involved.
3. Earthquake professions are found to have advocacy roles in addressing all 23 weaknesses. Professional engineers have engineering technical actions in addressing two-thirds (15) of the weaknesses.
4. The complexity of the processes of remedying the weaknesses is shown by the fact that nine of the weaknesses could have remedial actions from five or more parties.
5. The concept of a periodic Warrant of Fitness for a structure or other property appears to have considerable potential for dealing with existing property, and with changes which reduce earthquake performance, e.g. cutting holes in structure, or poor maintenance.
6. Duty of care for the public gives all parties more responsibility for remedial action than many people may realise.
7. The potential exists for reducing financial losses in future earthquakes by about an order of magnitude, i.e. billions of dollars and thousands of casualties if the whole of the built environment were to be converted to the lower bound of earthquake vulnerability.
8. New Zealand has many strengths (16 listed here) which provide a good framework for addressing the huge task of earthquake risk reduction.

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Table 1: List of New Zealand's strengths in earthquake risk reduction

People Attributes
Competent earthquake research (engineering, geology, seismology)
Competent engineering and architectural design
Competent construction industry
Competent enforcement
Competent emergency planning and management
Control of the Built Environment
Earthquake design regulations for new property
Regulations for retrofitting unreinforced masonry
Houses mostly timber-framed
Good construction materials available
Good progress on protection of lifelines
Societal Attributes
Minimal corruption
Above average national financial resources
Moderate degree of poverty
Strong bureaucracy, and strong education, communication and IT systems
Widespread earthquake insurance
A close-knit and co-operative society, with strong international links

Table 2(a): Part 1 of the Preliminary List of New Zealand’s weaknesses in earthquake risk reduction (please notify author of any errors or omissions)

A Undesirable situations - strategic		Remedial action by whom										
		A	E	a	I	M	P	G	g	L	F	O
A1	No national strategy and targets for managed incremental risk reduction with time	A	E			M		G	g	L		
A2	Too much national vulnerability to a “king-hit” earthquake on Wellington	A				M		G		L		
A3	Fragmentation of the many endeavours contributing to earthquake risk reduction	A					P	G	g	L		
A4	Underfunding of production of design codes and standards	A						G			F	
A5	Systematic reduction of the numbers of hospitals/beds nationwide	A					P	G	g		F	
A6	Too little management/modelling of business interruption losses	A			I	M	P	G	g	L		O
A7	Slow uptake of some new research findings	A					P	G	g	L	F	O
A8	As yet no official process for retrofitting of non-URM earthquake risk buildings	A	E					G	g	L		O
A9	Too much emphasis on life safety at the expense of high damage (e.g. EBFs)	A	E									O
A10	Over-design in New Zealand’s lowest seismic hazard regions		E				P			L		
A11	Architects who don’t collaborate with engineers structural form needs	A		a								O

Notes: A = Advocacy by earthquake professions; a = Architects; E = Engineers; F = Funding needed; G = Central Govt; g = govt dept; I = Insurance industry; L = Local govt; M = Economists; O = Owners of property; P = Planners;

Table 2(b): Part 2 of the Preliminary List of New Zealand's weaknesses in earthquake risk reduction (please notify author of any errors or omissions)

B Undesirable situations - tactical		Remedial action by whom										
		A	E	a	I	M	P	G	g	L	F	O
B1	No EQ regulations for most equipment and plant	A	E					G	g			
B2	Inadequate EQ regulations for building services in buildings	A	E					G		L		O
B3	Inadequate EQ regulations for storage of stock in shops and warehouses	A	E					G	g	L		O
B4	No adequate regulatory framework for existing high risk concrete and steel buildings	A	E					G	g			
B5	Weak powers and weak action for pre-emptive land-use planning (f, l, *l*, m)[1]	A					P	G		L		
B6	Buildings astride active faults	A	*EG*[2]		I		P		g	L		O
B7	Modern buildings built without measures for liquefiable ground	A	E				P			L		O
B8	Inadequate enforcement of some regulations	A	E		I		P	G		L		O
B9	Incomplete and/or inadequate microzoning maps nationwide	A	*EG*				P			L		
B10	Some councils renting out or using Earthquake Risk Buildings	A	E		I		P			L		
B11	Are all new materials and techniques adequately researched before use? (e.g. "chilly bins")	A	E		I				g	L		
B12	No regular checks on seismic movement gaps for seismically isolated structures	A	E		I					L		O

Notes:

(1) (f,l,*l*,m) = faults, landslides, liquefaction, microzoning;

(2) *EG* = Engineers + geologists. For explanation of other abbreviations A, E etc see Table 2(a).

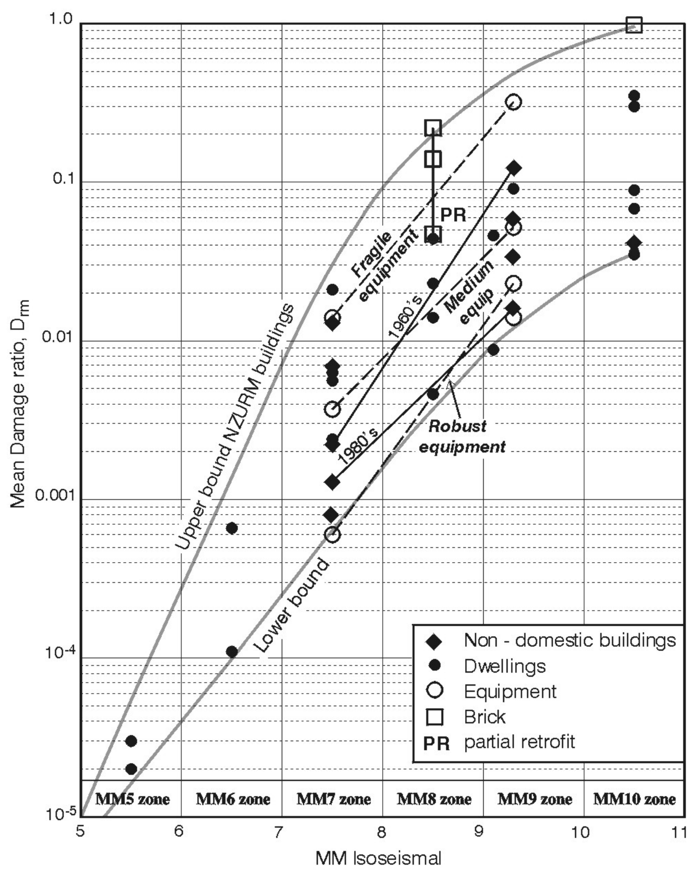

Figure 1 Mean damage ratio data from New Zealand earthquakes for buildings and equipment as a function of intensity, with approximate upper and lower boards.